POWER PLANT ENGINEERING

Established Over 31 Years

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When Is a Penstock?

BEING AVERSE, in our wife's name, to the use of strong language except under certain trying conditions when we need it, we hesitate to report what the unfortunate mechanic said who discovered when a penstock isn't. But, the story is exciting even if true.

In a small isolated hydro plant the gates were shut and the casing and short penstock drained, so that the wheel might be repaired.

Next reel—a goat belonging to the engineer's small boy, managed to get through the loosened planks back of the gates and slid down the penstock so that he was in a strategic position.

Came the mechanic as he backed down the ladder.

What followed sounded like a riot call in a boiler shop.

Minutes later—the poor mechanic had been rescued and convinced that dragons and goblins had not returned, limping and disgusted, he declared that he knew a lot of engineers who twisted up their words but that was the first time he ever knew one who made a stock pen out of his penstock.

This is not, of course, the reason why in practice penstocks are provided. In the usual course of events a penstock comes with a hydro plant just as a tail usually comes with a dog. The 1300-ft. steel penstock shown above came with Oak Grove Station. To test this unit, a new method was developed—not by goat power.

Now having explained when a penstock isn't, we refer you to the article on page 1086 to read about making tests in plants where a penstock is.

Power for the New Penn Athletic Club

POWER PLANT FOR NEW PHILADELPHIA CLUB BUILDING DOES NOT GENERATE OWN ELECTRICITY BUT SUPPLIES ALL OTHER COMMODITIES. ALL EQUIPMENT INSTALLED IN DUPLICATE OR TRIPLICATE TO INSURE CONTINUITY OF SERVICE UNDER EMERGENCY CONDITIONS

UPON THE SUCCESSFUL completion of the magnificent new 14-story building of the Penn Athletic Club, opposite Rittenhouse Square, in Philadelphia early in 1926, the Quaker City became the home of what is, without doubt, the finest athletic club building in the country. Erected at a total cost of six million dollars, this building not only provides every facility of the finest hotels, but also those for the enjoyment of every conceivable form of athletic activity. From its beautifully appointed main dining room on the main floor to the indoor tennis courts and golf courses and the swimming pools on the upper floors, everything relating to club life and athletic activity has been included. There are handball courts and squash courts, card rooms, billiard rooms, bowling alleys, indoor tracks and basket ball courts, shower baths, electro- hydro- and mechanico-therapeutic rooms, etc. In addition to the purely athletic facilities, there are five floors of bedrooms having a total of 250 rooms, some of them with sitting rooms attached. In addition to the main dining room there are a number of private dining rooms as well as a grill and a women's dining room.

From this brief description which is not intended to be complete, it is obvious that to supply a building of this type with light, water, power and heat requires a power plant of considerable proportions and one which, because of the nature of the service, with a high factor of reliability.

The power plant, which is located in the basement and sub-basement, supplies all of these commodities, but does not generate electricity. All electric current used in the Club is purchased from the Philadelphia Electric Co. This current is obtained from two separate generating stations over separate lines, one of which ordinarily supplies the lighting system and the other the power system. Steam for treating and cooking as well as for the laundry is furnished by oil fired water-tube boilers which may, however, be arranged for coal burning if the use of coal should prove more economical in the future.

The general arrangement is shown in Fig. 2. The boilers are located in the sub-basement, two floors below the street level in a spacious, well-lighted room which extends up two floors, giving ample room above the boilers for piping. The fuel oil pumps, heaters and filters are isolated in a small room where they can be easily cut off by fire doors from the remainder of the sub-basement. Service pumps for general water supply are located in another good sized room adjacent to the boiler room and the fan room is beyond that. The main switchboard and the ballroom switchboards are also located here.

The refrigerating room is directly behind the boiler room as may be noted and just above this on the basement floor, are the house tanks, pool filters and hot

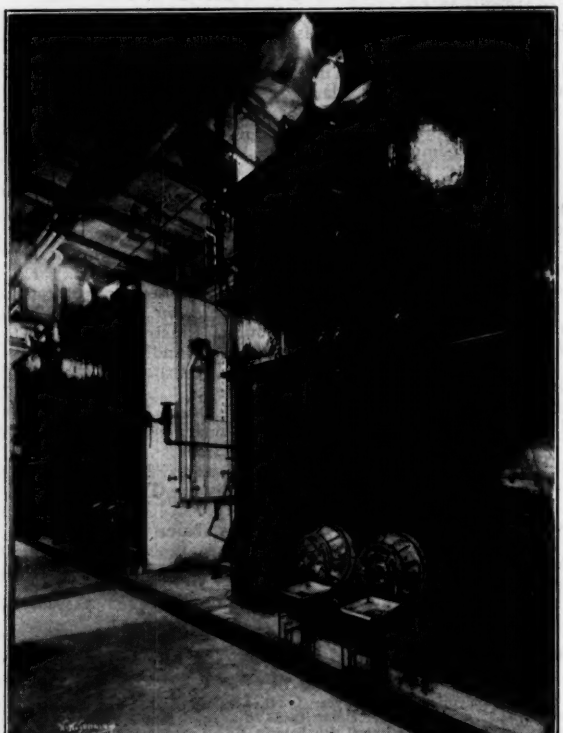


FIG. 1. EACH OF THE THREE 310-HP. BOILERS IS FITTED WITH TWO OIL BURNERS

water generators, the latter being shown in Fig. 6. The laundry, which is equipped with the most modern type of laundry machinery occupies the corner of the sub-basement near the fan and pump rooms.

Plant Has Three 310-Hp. Boilers

Three Union Iron Works, cross drum boilers, rated at 310 hp. each are installed. They have an allowable working pressure of 175 lb. but are operated normally at 110 lb., only one boiler being used at one time. The high pressure is required for the valet and laundry machines. In the kitchen and Turkish bath steam at 30 lb. pressure is used. The hot water generators operate at from 5 to 12 lb. while, for heating the building, only 2 to 5 lb. is required in the coldest weather.

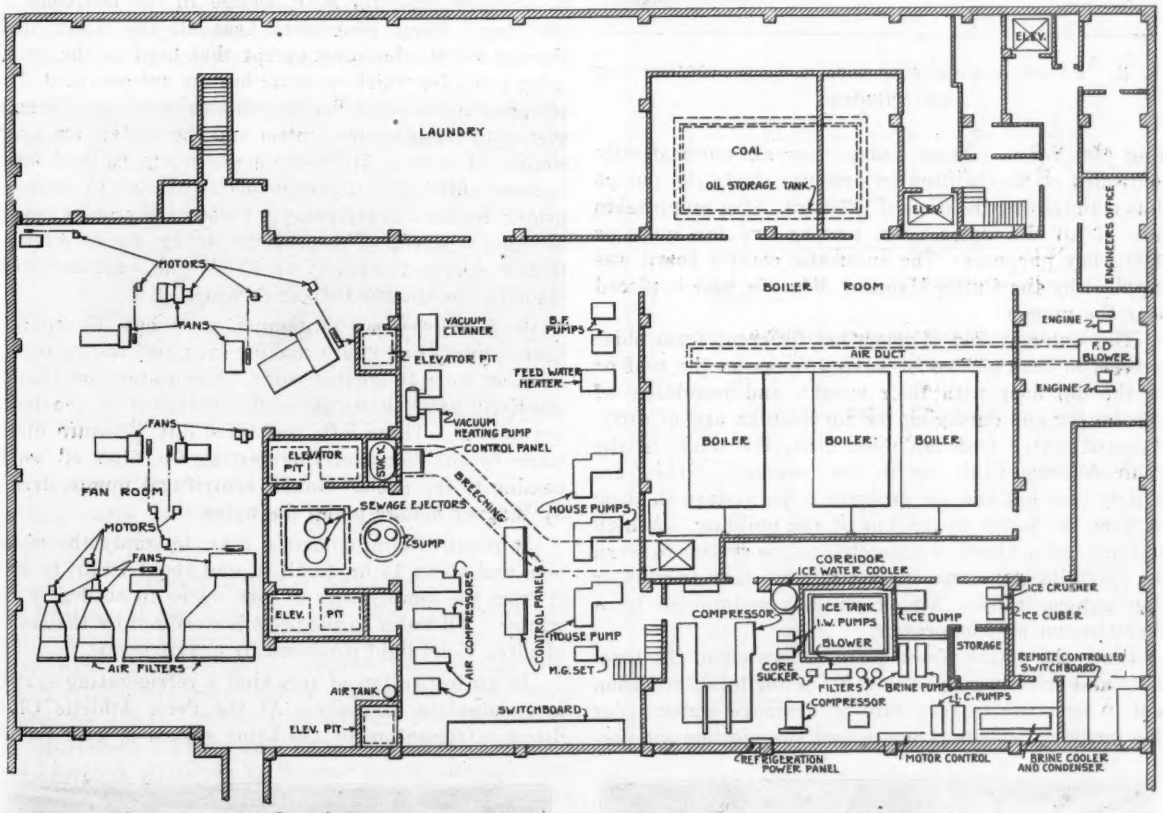


FIG. 2. GENERAL ARRANGEMENT OF EQUIPMENT IN THE SUB-BASEMENT

All boilers are oil fired by the Peabody wide range oil system, which makes it possible to operate over a range from 15 to 100 per cent capacity without having to change burner tips.

Equipment included in this oil burning system, consists of a 15,000-gal. fuel oil storage tank installed underground, three Kinney Mfg. Co. motor driven fuel pumps, two Andale Engineering Co. oil heaters and two Andale filters. Of the three pumps, two are driven through reduction gears by 3-hp. Wagner motors operating at 1140 r.p.m. and the third, direct driven by a 2-hp., 860-r.p.m. Wagner motor. The fuel oil is heated to a temperature of 260 deg. F. and is delivered to the burners under a pressure of 225 lb. Each boiler is fitted with two Peabody burners, these being placed about 2½ ft. above the floor.

This system is designed to handle the heaviest grade of oil fuel as well as the lightest. Every precaution has been taken against fire or explosion. The 15,000-gal. storage tank is provided with a direct filling line from the street and the system is fitted with a Schutte & Koerting fire protection valve which instantly shuts off the main oil supply in case of a line bursting.

As may be seen from the photograph, the boilers are fitted with all-steel fronts, presenting a neat appearance. Boiler accessories are provided as follows: Four Lonergan safety valves, Golden-Anderson non-return stop valves, Copes feed water regulators, Reliance Water columns, Yarway blowoff valves and Vulcan soot blowers. Other instruments provided include a Brown Electric CO_2 recorder and pyrometer, and a Cochrane steam flow meter.

Feed water is obtained from the city mains and after being heated in a Cochrane open type heater is pumped into the boiler by two vertical Warren steam pumps. These are simplex units, 10 by 6 in. with a 24-in. stroke, and provided with Copes back pressure regulators. A Cochrane flow meter with a maximum capacity of 34,000 lb. of water per hr. at 200 deg. F. is installed for measuring the amount of feed water passing the boilers.

In addition to the water used in the boilers, a great quantity of water is needed in a building of this kind for all sorts of purposes and it is the function of the power plant to supply this water and to heat it or cool it to the proper temperatures.

For general water service throughout the building three Worthington triplex pumps are provided, rated at 750 g.p.m. each and driven through Morse silent chains by 40-hp., 2-phase, 220-v. Fynn-Weichsel motors run-

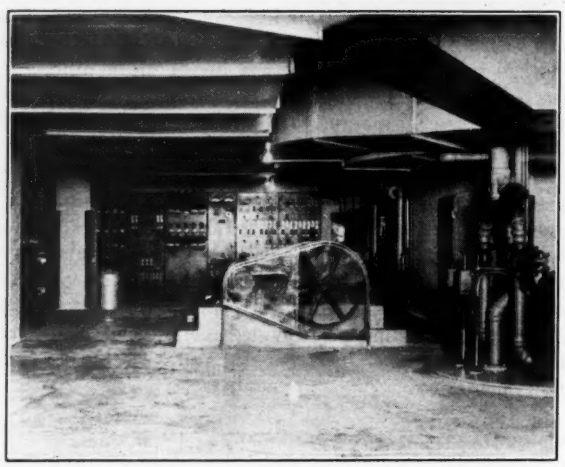


FIG. 3. A VIEW IN THE PUMP ROOM LOOKING TOWARD THE SWITCHBOARD

ning 900 r.p.m. These pumps are all automatically controlled so that a drop in pressure starts the pumps thus maintaining the desired pressure. One pump takes care of all the water used, leaving two for spare or emergency purposes. The automatic control board was supplied by the Cutler-Hammer Mfg. Co. and is placed near the pumps.

The water system is somewhat different from older systems in that instead of having tanks on the roof or on the top floor with their weight, and possibility of overflowing and damaging the furnishings, and of dirty, stagnant water from an open tank, the tanks in the Penn Athletic Club are in the basement. They are strictly enclosed and air pressure is maintained in them to force the water to the top of the building. A high and low water alarm is connected to the system to warn the operating personnel in case a pump fails to start or stop automatically. Air pressure is maintained by a Worthington air compressor.

Since the entire power plant is located in the basement and sub-basement, below the sewer level, provision had to be made to take care of drainage water. For this purpose, two sump pumps and two ejectors are provided. The sump pumps are Chicago Pump Co. units, driven by Wagner motors and controlled automatically by a float switch. The ejectors are Shone ejectors made by Yeomans Bros. Co., and are operated by two (duplicate) Pennsylvania air compressors with a 7½-in. air cylinder and a 6-in. stroke supplying compressed air at 100 lb. pressure. This unit is driven by a 15-hp., 350-r.p.m., 60-cycle, 2-phase Fynn-Weichsel motor, controlled automatically by Cutler-Hammer equipment.

Hot Water Supply

Hot water for general use is supplied by five Whitlock hot water generators, only three of which are ever used at any one time. These are shown in Fig. 6. Water to the kitchen is heated to 160 deg., to the laundry at 170 deg., and for bath service in the bedrooms to 140 deg. These generators heat all the water used throughout the building except that used in the swimming pools for which separate heaters are provided. The temperature is controlled automatically by the Johnson system of temperature control and the heaters are cross connected so as to allow one generator to be used for a system which is ordinarily taken care of by another heater, in case of emergency, or while the regular heater is being cleaned. The pressure storage tanks referred to above have a capacity of 10,000 gal. each and were made by the Quaker City Iron Works.

Each of the two swimming pools has its separate heater, pump and filters, making each pool and its equipment an entirely separate unit. The heaters are Patterson-Kelly units thermostatically controlled by the Johnson system. Three 5-ft. and three 3-ft. pressure filters made by the Norwood Engineering Co. filter all water passing to the pools. Goulds centrifugal pumps driven by Wagner motors pump the water.

It requires approximately 3 hr. to empty the men's pool and about 13 hr. to fill it, and about 18 hr. to heat it from the temperature of city water to 80 deg. F. in winter. All water to the pools is sterilized by the action of ultra violet light produced by quartz lamps.

In an institution of this kind a refrigerating system is an absolute necessity. At the Penn Athletic Club, direct refrigeration by the brine system is used for all

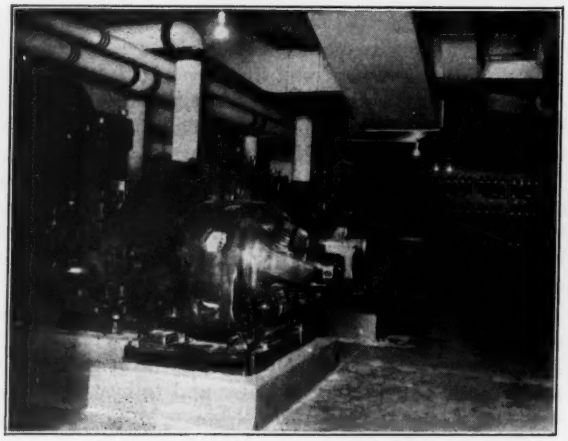


FIG. 4. THREE TRIPLEX PUMPS SUPPLY WATER FOR GENERAL PURPOSES

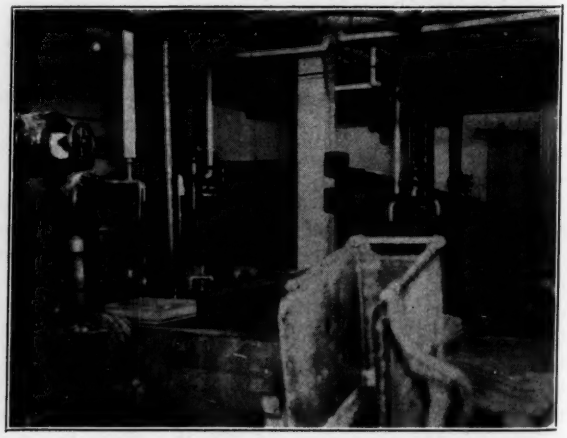


FIG. 5. THIS REFRIGERATING PLANT SERVES 60 REFRIGERATORS THROUGHOUT THE BUILDING

of the 60 refrigerators throughout the kitchens and storerooms as well as for the drug store and florist's shop in the building. This also cools the circulating drinking water throughout the building, and manufactures 3 t. of cake ice each 24 hr.

Figure 2 shows the arrangement of refrigerating equipment in the sub-basement. Three ammonia compressors supply the cooling effect. Two of these are horizontal double acting machines, rated at 25 t. and the other, a vertical, twin cylinder unit, rated at 7½ t. All machines are of Vilter manufacture and driven by Fynn-Weichsel motors with Industrial Controller Co. control. Other equipment in the refrigerating room includes a shell type brine cooler, two brine pumps for general brine service throughout the building, two brine pumps for the ice cream plant, an ice crusher and an ice cuber and a water cooler. The ice tank is located in the center of the room as shown on the plan. The arrangement of equipment allows ample space between

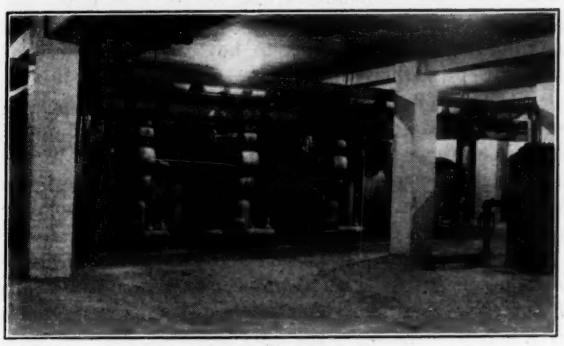


FIG. 6. THE HOT WATER GENERATORS

moving parts. All belts and pulleys are fully guarded by steel guards.

Heating and Ventilating

Heating of the building is by both the direct and indirect steam system. This system is of the vacuum type, Nash Engineering Co., vacuum pumps being provided. These are motor driven pumps, each unit being driven by a 5-hp., 220-v. G. E. motor. For ventilating, 22 Sturtevant blowers and four R. N. Gerdes blowers are provided, all driven by Wagner motors through belts but some direct connect. The air is purified by Reed air filters. All public rooms such as dining rooms, card rooms, lounge, athletic auditorium, lobby and ball room are equipped with Johnson Service Co. temperature control.

Electrical Features

Current purchased from the Philadelphia Electric Co. is stepped down by four 2300/230/115-v. transformers located in a specially constructed transformer room. Two of these ordinarily supply current for lighting service and the other two current for power service. Ordinarily two transformers are connected to a line from one generating station and the other two to a line from another generating station. In case trouble occurs on either line, however, the four transformers can all be supplied from one line and the power and lighting system of the club supplied as normally. This arrangement has worked out very satisfactorily. Not long ago, when, because of a transformer failure in one of the substations on the power system, on a night when an important entertainment was being held in the main ballroom the line supplying the power service went "out," the lights merely flickered a moment and service continued as though nothing had occurred. The motors in the building, of course, stopped and had to be restarted and the power system thrown over to the other incoming power line, but the public in the ballroom were unaware that anything unusual had happened. Other hotels, office building and theatres in the meantime were without service from 15 to 30 min.

Control and distribution of all electric current is effected by a 14-panel vertical switchboard located at

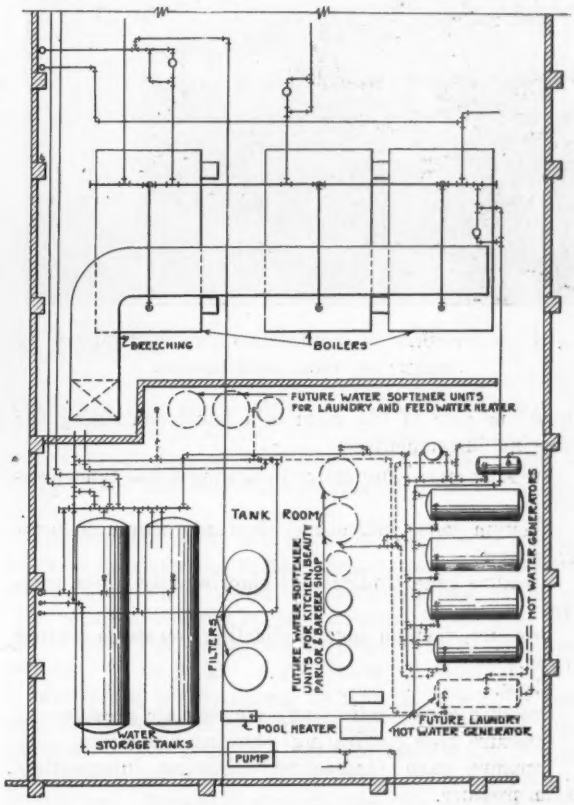


FIG. 7. PLAN SHOWING ARRANGEMENT OF HOT WATER GENERATORS AND STORAGE TANKS

one end of the pump room. This was designed and manufactured by the Walker Electric Co. of Philadelphia. The circuit breakers are the Cutter Electric Co.'s and the meters are all of Weston make. Motors throughout the club building are controlled by Urelite switches. The Fynn-Weichsel motors installed help to balance the load of the induction motors and a power factor of 89 per cent is maintained.

The electric service is two phase, four wire. The load is quite large, besides a multitude of motors for all services, in the kitchens, laundry, ventilating room, refrigerating plant, on the elevators and pumps, the lighting load is large. The building is filled with hand ball, basket ball, tennis courts, golf courts and swimming pools and these all require high intensity illumination. The supplying of these alone is no small item. There

is also a considerable amount of stage and ballroom lighting, requiring not only large current, but also special equipment, such as dimmers, for its control. The ballroom switchboard and the dimmers are all of Cutler-Hammer manufacture.

Management and Operation

The chief engineer's office is a glass enclosed room, mechanically ventilated, located just off the boiler room as shown on the plan of the sub-basement. It is provided with ample desk facilities and filing cabinets for the permanent filing of records and power plant data.

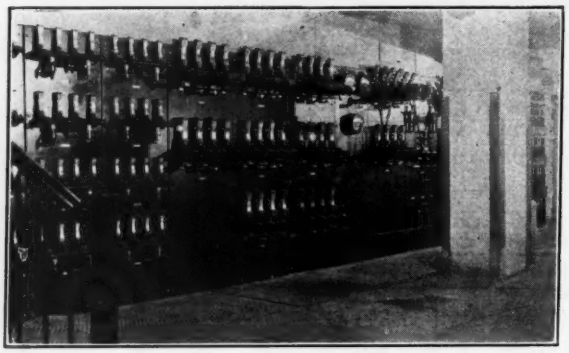


FIG. 8 ELECTRICITY IS CONTROLLED AND DISTRIBUTED BY MEANS OF THIS SWITCHBOARD

Along one side of the room is a panel containing the following instruments:

Pressure gage (indicating) showing house tank pressure.

Vacuum gage (indicating) showing vacuum on heating system.

Pressure gage (indicating) showing city water pressure.

Pressure, vacuum gage (indicating) on steam heating system.

Clock.

Pressure gage (indicating) showing air pressure.

Pressure gage (indicating) showing h.p. steam.

Pressure gage (indicating) showing intermediate steam pressure.

Pressure gage (recording) showing h.p. steam.

Pressure gage (recording) showing intermediate steam pressure.

Electric CO_2 indicator.

All of these instruments with the exception of the CO_2 indicator are Foxboro units. The CO_2 indicator is a Brown Instrument Co. machine.

The plant is in charge of Warren C. Evans, chief engineer, who has with him seven licensed assistant engineers. There are two men on each 8-hr. shift, the seventh man being a relief man. Each man gets one full day a week off. Mr. Evans himself is an ex-marine man. He came to the plant direct from an ocean liner where he served as chief engineer for 7 yr. and many other years in lower ratings, having worked himself up from coal passer to the highest engineering position aboard American ships.

His long experience at sea has convinced him of the resourcefulness of the marine engineer and for his assistants he has selected mostly ex-marine men. Besides the seven assistant engineers the chief has under his charge, two carpenters, five painters, one plasterer, three electricians, one plumber, one fitter, four utility men, one stage manager, two elevator operators (freight), two watchmen, one relief man and one clerk.

In concluding this article, we wish to acknowledge our indebtedness to Warren C. Evans, chief engineer, for his assistance in the collection of data for this article and to the firm of Isaac Hathaway Francis, consulting engineers, for supplying the drawings.

Operating Experiences With Economizers

SOME OF THE MORE important points brought out by the N. E. L. A. in a recent investigation of experience with economizers lead to three general conclusions: First, the present tendency in connection with steaming economizers seems to be towards the use of soot blowers rather than water washers, particularly when the unit is in operation. Water washing is, however, still used in some cases when the unit is down. Second, extreme care must be taken in rolling in the tubes in high pressure installations. Third, it appears that the exact value of the lead alloy coated economizer has not yet been determined.

Two companies report some trouble from breakage in fitting the tubes in cast-iron economizers as the result of defective castings. One of these companies reports satisfactory cleaning with soot blowers, but believes that water washing should also be provided for.

Another company reports that there is no evidence of any pitting on steel economizer tubes after six years of service. The economizers are shut down once a year and soft corrosion is removed. There is some slight leakage after cleaning but these leaks generally take up when the economizers become warm. Two companies report no trouble whatever due to internal or external corrosion; soot blowers are used to keep the tubes clean but it has been necessary to resort to water washing as well. One of these companies states that its feed water is free from oxygen due to having a closed system and deaerating hotwells.

Two additional companies report slight internal corrosion due, probably, to the deaerators not being 100 per cent effective. One of these companies also reports a case of tube sweating resulting in external corrosion. This, however, was remedied by correcting the feed water temperature.

Lakage at the point where the tubes are extended into the header was reported in one case but the leakage was not serious enough to necessitate taking the boiler out of service. Numerous water spray lines were installed at this plant for cleaning. It was found most advantageous, however, not to use these until the unit was taken out of service and had cooled down, at which time the tubes were thoroughly washed down with cold water. No apparent trouble with either corrosion or erosion has been experienced in 15 months' time. Soot collecting between the headers and casings due to poorly fitted baffles between the headers was overcome by slightly changing the adjustment of the soot blowers.

Calculating Extraction Turbine Performance

DETAILS OF METHOD USED IN LOCATING FEED WATER HEATERS FOR BEST ECONOMY, CALCULATING STEAM TO BE BLED AND GAIN IN EFFICIENCY OVER NON-EXTRACTION OPERATION. BY K. S. KRAMER[1]

IN A PREVIOUS article[2], the author presented a series of curves intended to show, comparatively, the gains to be obtained by heating the feed water in from one to five stages by steam bled from the turbine and a specific set of steam conditions. Although they may be applied, with reasonable accuracy, to other conditions, it is quite possible that where the deviation from the stated conditions is great, the amount of the resulting inaccuracy may be such as to necessitate recalculation for the conditions of the problem at hand.

For this reason, it is felt that a presentation of the methods of calculation used in formulating the curves given in the previous article, may prove useful. In order to avoid unnecessary complication, however, the discussion will be confined to a particular size unit with a given set of steam conditions and a given number of stages of feed heating. The conditions are as follows:

Load, 70,000 kw.; steam, 550 lb. per sq. in. gage, 725 deg. F. total temperature, 29 in. vacuum; feed heating in three stages to a final feed temperature of 320 deg. F.; constant stage efficiency, 82 per cent; generator

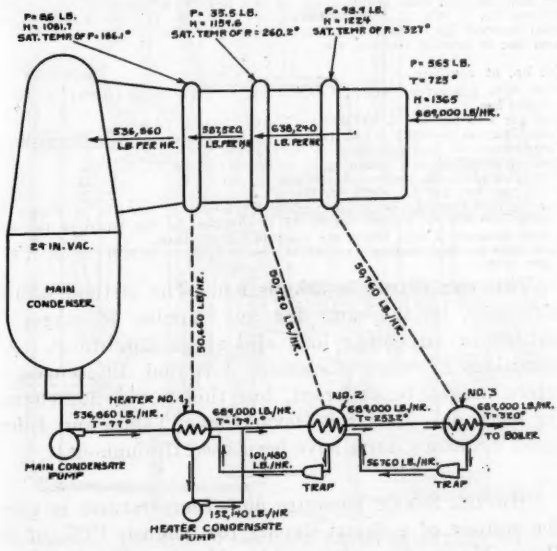


FIG. 1. DIAGRAMMATIC ARRANGEMENT OF EXTRACTION HEATERS FOR THREE STAGES OF FEED HEATING

efficiency, 96 per cent, and the heater arrangement as shown in Fig. 1.

Total steam flow to the throttle is the first value required. This is found by a cut-and-try method but can be closely estimated with the help of the curves shown in Fig. 2, and a calculation of the throttle flow for operation without feed heating. For the throttle conditions of 565 lb. per sq. in. absolute, 725 deg. total temperature, the total heat per lb. of steam, H = B.t.u. and entropy, N = 1.608. Assuming a 25 lb. drop across throttle and governor valves, we have at the turbine inlet: P = 540 lb. per sq. in. abs.; H = 1365 B.t.u. and N = 1.612. The total B.t.u. drop from turbine inlet to exhaust at constant entropy, N = 1.612, and the resultant B.t.u. into work are as follows:

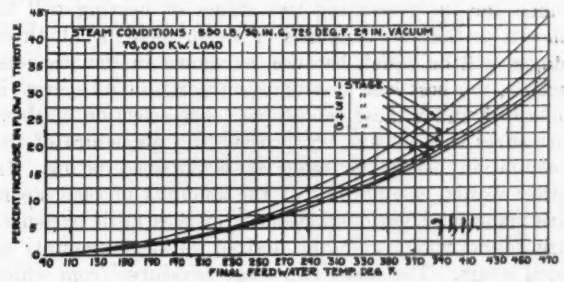


FIG. 2. CURVES USED TO APPROXIMATE THE STEAM FLOW TO THE THROTTLE

H_1 at 540 lb. per sq. in.	= 1365	B.t.u.
H_2 at .49 lb. per sq. in.	= 866.5	B.t.u.
Adia. heat drop, $H_1 - H_2$	= 498.5	B.t.u.
Stage efficiency	= .82	
Converted into useful work	408.8	B.t.u.

70,000 kw. at 96 per cent generator efficiency requires 97,720 hp., so that 70,000 × 1.3405 ÷ .96 = 97,720 b.hp. that the turbine must deliver to the generator.

Assume that there is a loss of 800 hp. due to friction of main bearings and thrust bearing, power required to drive the governor, gland loss, radiation loss, et cetera. The required internal hp. is, therefore, 97,720 plus 800, or 98,520. The steam flow to throttle in lb. per hour will be: W = 98,520 × 2545 ÷ 408.8 = 613,000.

Referring to the curves on Fig. 2, it will be seen that for three stages of feed heating to a final feed temperature of 320 deg., 12.4 per cent more steam flow to the throttle is required to maintain the same load of 70,000 kw. Estimated throttle flow for the feed heating condition is, then, 1.124 × 613,000 or 689,000 lb. per hour.

WATER IN HEATERS CAN BE BROUGHT TO WITHIN 7 DEG. OF STEAM TEMPERATURE

Having found the steam flow, the next step is to find the absolute pressure in the turbine at the stages from which steam is to be extracted. The heaters are simply a series of surface condensers, which condense the bled steam, the latent heat of which is given to the feed water flowing through the heater. The temperature of the feed water leaving a given heater can, therefore, be no greater than the saturation temperature corresponding to the pressure in the turbine stage from which the heating steam is bled.

In practice, however, because of pressure drop and other losses, the temperature of the feed water leaving a given heater is actually somewhat less than the saturation temperature of the pressure in the turbine. This

[1]Turbine Eng. Dept., Westinghouse Elec. & Mfg. Co., South Philadelphia Wks.
[2]Page 817, Aug. 1, 1927, issue.

difference, in the calculation presented, is taken as 7 deg. for each heater. In order, then, that the final feed temperature may be 320 deg. (the temperature of the feed water leaving the hottest heater), the heating steam for the hottest heater must be bled from a turbine stage at which there is an absolute pressure of 98.9 lb. per sq. in. (corresponding to a saturation temperature of 327 deg. F.).

Pressure zones from which the bled steam is to be taken for the remaining two stages of heating will be chosen so that the amounts of steam bled for all three stages will be equal, because, as shown in the previous article, the best heat consumption per unit of energy is obtained under these conditions. The selection of these pressures is a cut-and-try process, the procedure of the calculation being the same as is outlined below. In other words, calculations of the amounts of bled steam are made with various bleeder pressures until pressures are found which give the desired ratio of amounts of bled steam. The other two stage pressures from which steam is bled will be taken as 35.5 lb. per sq. in. abs. and 8.6 lb. per sq. in. abs.

Calculations are given below in tabular form and, by referring to Fig. 1, should be easily understood. It might first be noted that the pressure drop in the steam line between the turbine and the heater in each case is assumed to be such as to give a drop in saturation temperature of 1 degree. Also, that the temperature of the condensate in each heater is assumed to be 2 deg. less than the saturation temperature corresponding to the pressure in the heater.

Condensate from each of the upper two heaters is led through a trap to the next lower heater. This condensate is evaporated in part in the heater to which it is led and thereby reduces the amount of steam required for heating at this stage. The condensate from the coldest heater is pumped into the feed line following this heater, thereby raising the temperature (or heat of the liquid) of the feed water entering the next heater. The amount of this rise must first be assumed and then checked by the calculation shown. The amount of feed water flowing through the coldest heater must likewise first be assumed and then checked.

First values to be found are the total heat per pound of steam at the various bleeder points:

		Ø = 1.612			
P=540 lb.—H=1365	98.9	—1193.0	35.5 lb.—1114.5	8.6	—1019.5
P= 98.9lb.—H=1193	35.5 lb.—1114.5		8.6 lb.—1019.5	.49 lb.—	866.5
B.t.u. drop 172		78.5		95.0	153.0
Stage eff. 82		.82		.82	.82
B.t.u. into work. 141.0		64.4		77.9	125.5

Actual total heat per pound of steam at each bleeder point is, therefore: 1365 — 141 = 1224 B.t.u. per lb. at 98.9 lb. per sq. in. abs.; 1224 — 64.4 = 1159.6 B.t.u. per lb. at 35.5 lb. per sq. in. abs. and 1159.6 — 77.9 = 1081.7 B.t.u. per lb. at 8.6 lb. per sq. in. abs.

HEATER NO.		1	2	3
STEAM CONDITIONS IN TURBINE				
Pressure in turbine at bleeder point lbs. per sq. in. absolute	P	8.6	35.5	98.9
Total heat per pound of steam	H	1081.7	1159.6	1224.
B.T.U. AVAILABLE FOR HEATING				
Saturation temperature for pressure P in turbine	T′	186.1	260.2	327
Saturation temperature for pressure in heater, T′-1	T″	185.1	259.2	326
Temp. of condensate in heater, T″-2	t	183.1	257.2	324
Heat of the liquid for temp. t	q	151.0	225.8	294.3
B.t.u. available per pound of steam bled (H-q)	AH	930.7	933.8	929.7
B.T.U. REQUIRED FOR HEATING				
Temperature of feed leaving heater, T′-7 deg.	t′	179.1	253.2	320
Heat of liquid of feed leaving heater	q′	147.0	221.7	290.2
Heat of liquid of feed entering heater.	q″	45.0	147.0	221.7
B.t.u. rise of feed in heater	q	102.0	73.8	68.5
Feed flowing through heater, lbs. per hr.	F	536,860	689,000	689,000
B.t.u. required for heating q x F Thousands of B.t.u. per hr	Q	54,759	50,848	47,197
WEIGHT OF STEAM BLED				
Heating steam required, Q ÷ AH lbs. per hr.	M′	58,820	54,450	50,760
Cond. from upper heaters evaporated in each heater, lbs. per hr	C	8,160	3,730	0
Net weight of steam to be bled, M′-C lbs. per hr	M	50,660	50,720	50,760
HIGH TEMPERATURE CONDENSATE EVAPORATED IN LOWER HEATERS				
Total steam bled to all higher heaters.	M″	101,480	50,760	.....
Condensate B.t.u. drop upper to next lower heater	q′	.....	74.8	68.5
B.t.u. available to evaporate incoming H.T. Cond. q′ × m″	Q′	.....	7,590,000	3,480,000
AH for next lower heater	AH′	.....	930.7	933.8
High Temp. Condensate evaporated in next lower heater, Q′ ÷ AH′	C′	.....	8,160	3,730
HEAT OF LIQUID OF MIXTURE ENTERING HEATER				
Weight of feed leaving heater	F	.....	536,860	.....
Heat of liquid of feed leaving heater	q′	.....	147.0	.....
Weight of condensate added to feed	M	.....	152,140	.....
Heat of liquid of condensate added to feed	q	.....	151	.....
Total heat in feed, F × q′	Q″	.....	78,918,420	.....
Total heat in condensate, M × q	Q″	.....	22,973,140	.....
Heat of liquid of mixture (Q″ — Q″) ÷ (F — M)	q″	.....	147.88	.....

There now remains the calculation of the B.t.u. rate.

B.t.u. into work for each blade group as previously calculated	H	141	64.4	77.9	125.5
Total flow to each blade group	W′	689,000	689,000	638,240	587,520
Steam bled	Wb	0	50,760	50,720	50,660
Net flow through each group	Wn	689,000	638,240	587,520	536,860
Internal hp. = Wn × Hw ÷ 2545	HP	38,130	16,150	18,000	26,470
Total internal hp.		98,750			
Loss due to bearing friction, etc		800			
Net hp. at coupling		97,950			

With 96% generator efficiency 97,950 hp. = (97,950 ÷ 1.3405) × 96 = 70160 kw.

Lbs. per kw. per hr. = 689,000 ÷ 70,160 = 9.82

Total heat at throttle, B.t.u. per lb	H	1365
Temperature of feed returning to boiler, Deg. F	T	320
Heat of liquid of feed returning to boiler, B.t.u. per lb	h	290.2
Heat chargeable to turbine, B.t.u. per lb. (H-h)	Hc	1074.8
B.t.u. per kw. per hr., 9.82 × Hc	Rb	10,550

For no feed heating the B.t.u. per kw-hr. would be 613,000 ÷ 70,000 × (1365 — 45) = 11,560, where 45 is the heat of the liquid in the hotwell assumed 2 deg. below the vacuum temperature.

Gain over no feed heating — [(11,560 — 10,550) ÷ 11,560] × 100 = 8.74 per cent.

This completes the calculation. The method would, of course, be the same for any number of stages of heating or any other load and steam conditions. Assumptions of stage efficiencies, terminal differences, et cetera, might be different, but this would not change the methods. Marks' & Davis' Steam Tables and Ellenwood's Steam Charts have been used throughout.

HIGHER STEAM Pressure and Temperatures is given the subject of a Serial Report for August, 1927, of the Prime Movers Committee of the National Electric Light Association, 29 W. 39th St., New York, N. Y. The report gives the essential features of some 14 stations which have been initially started or added to within the past year. A summary of development in recent equipment follows. Discussion of experiences at several stations, including Edgar, Crawford Avenue and Philo, and abstracts from articles from abroad are presented. In addition, a comprehensive review of the relative properties of metals for use at high temperatures is given. The metals are divided into groups and their characteristics are discussed with the aid of tables and curves. Finally, comparative figures of the heat balance of various stations and a brief description of the essential features are given.

DO YOUR DUTY—you expect it of others.

Super-Pressure Turbine Built in Sweden

FOR 1500 LB. INITIAL PRESSURE, WITH MULTIPLE NOZZLE GOVERNING AND SINGLE IMPULSE WHEELS

BUILDERS of the De Laval turbine in Stockholm have recently completed two units to operate at 1500 lb. and 750 deg. F., exhausting at 90 lb., of 480 kw. capacity and designed for steam consumption of 26 to 28 lb. per kw-hr. One is for a German, the other for a Swedish plant. Details are given in Engineering of London, Eng.

Reduction gearing is used, stepping down from 15,000 r.p.m. of the turbine to 3000 r.p.m. for the generator. The turbine is two-stage, single impulse type

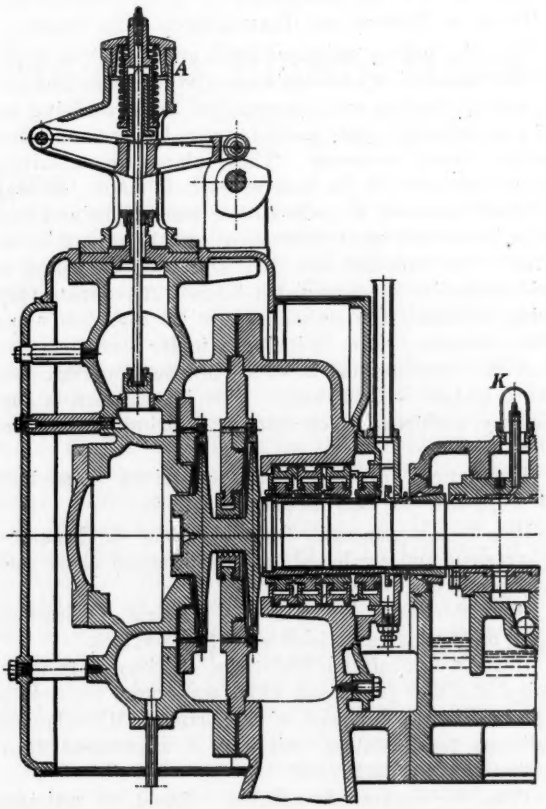


FIG. 1. TWO-STAGE IMPULSE ROTOR IS OVERHUNG

with overhung rotor as shown in Fig. 1. The entire rotor, shaft, wheels and double helical pinion for the reducing gear, is machined from a single forging. Wheels are 293 and 295 m.m. (11.535 and 11.614 in.) diameter giving a blade speed of 760 ft. a sec.

Steam enters the horizontal stop valve through a strainer and flows to a nozzle box in which four valves control independent groups of nozzles which come into action serially, according to the load carried, by means of cams actuated by the governor. Where full capacity is not needed, one or more of the nozzle groups may be omitted. Only such nozzles as are needed are in action, thus reducing throttling loss at light loads.

Overspeed is controlled by a special governor mounted on the 3000-r.p.m. shaft which closes the stop valve, in emergency, by means of an oil-pressure relay.

Nozzles are machined into rings which are fastened to the casing and to the diaphragm by bolts and set screws, the diaphragm between stages being slotted to correspond to the nozzle openings. First stage nozzles have an angle of about 15 deg., second stage about 12 deg. to the face of the nozzle ring.

Packing between shaft and diaphragm is as indicated in Fig. 1 but three collars are turned on the shaft to match with alternate fins on the packing ring so as to give a tortuous patch for any leakage steam.

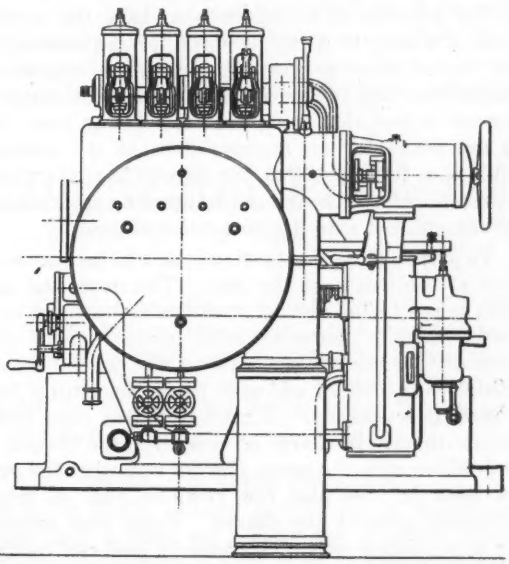


FIG. 2. ARRANGEMENT OF STOP VALVE, NOZZLE VALVE CONTROL AND GOVERNOR

End thrust is taken by a cap and block on the inner end of the shaft, a spherical block bearing on a like seat in the cap and oil being fed to the center through a bypass from the main inner-end bearing. Above each bearing is a glass bell, K, Fig. 1, into which oil escapes so long as the bearing is properly fed.

ALTHOUGH FROM the standpoint of the chemist the subject of petroleum lubricant is obscure, practical experience has shown that for most purposes, suitably refined oils of either base may be used with equal satisfaction. Certain differences in behavior, however, do exist and, in collecting an oil for a particular purpose, it is important that proper specifications, based upon actual service be used. That is a specification that would cover a satisfactory paraffine base oil might not insure good service if applied to a naphthene base oil.

FOR THE MONTH of August, 1927, the Department of Commerce announces that, according to reports from 12 establishments, a total of 160 stokers were sold, installed under boilers with total capacity of 60,979 hp. Of these, 60 stokers were installed under fire tube boilers of 9274 hp. capacity, and 100 stokers under water tube boilers of 51,703 hp. capacity. This is an increase of 24 stokers over the total of 136 sold in July, which were installed under boilers of 41,504 hp. capacity.

Outline of Compiling an Engineering Budget

Method of Estimating the Needs of Distribution System a Year in Advance. By Maurice D. Smith

PRESENT DAY accounting practice calls for an annual budget and as a consequence most electric light and power companies are called upon to compile a budget outlining the expenditures which will be required for the coming year. It is, therefore, the purpose of this article to outline the method adopted to compile the engineering budget of one company.

The purpose of a budget is to have the necessary funds available to carry on work for the coming year, that is, to have generating, substation, transformer, transmission and feeder capacity available to supply the increase in load that is expected the coming year. Since we are asked for an appropriation of the company's funds it is necessary that the figures finally arrived at must be founded upon sound judgment and engineering studies, and not exceed a reasonable request.

To arrive at the final estimate it will be necessary to start at the origin of the load. Therefore, the logical point is out in the district with feeder load and capacities in order to determine what feeder changes will be necessary for the coming year. A district fed from one substation is selected and each feeder emanating from it is studied separately. It may be stated here that the person directly in charge of compiling the budget must be familiar with the entire district and what the growth has been for the past few years so that he may intelligently predict the future. From past experience the approximate rate of increase in load can be figured and the expected load for the coming year estimated. This procedure is followed for each feeder and the results will show where the new feeders are necessary in a territory, whether wire and cable replacements are required, and, lastly, whether the regulators and station equipment require replacements for the coming year.

An inspection of the circuit maps will indicate whether the circuits are feeding a territory at a considerable distance from the station, in which case low voltage may result. This is definitely determined by an engineering study and if it is found, low voltage will result on a feeder, it will be necessary to construct a new feeder or substation to take over the load at the end of this feeder and to give satisfactory voltage. An inspection of the circuit maps will show any long single or two phase spurs with considerable load, which will require the running of additional phase wires and the balancing of load along this feeder.

The station feeder capacity determines whether the present station and equipment will be adequate to carrying the estimated load. It may be found that additional or larger transformer banks and switching equipment are required. The various station feeder loads indirectly determine the transmission lines feeding the stations, and if it is found load has been added to the station, it may be necessary to install additional transmission lines to take care of the load. The conversion of 4000-v. and 7500-v. customers to 13,000-v. service requires additional transmission changes, also, new customers contemplated will indicate a certain amount of transmission changes for the coming year.

These transmission and feeder changes may require new underground conduits. When the load of a certain section increases to such a point that it cannot be supplied with overhead transformers, transformer manholes, underground conduits, and secondary cables for a network must be installed to take care of the additional load.

Load and capacities and the number of street lamps added in past years is resorted to to determine the necessary street lighting changes to be made during the coming year.

Study of Feeder and Transmission Line Needs

Once the various estimated loads and capacities available for the coming year are known, studies are made of the various feeders and transmission lines requiring relief and tentative plans made for new feeders and other changes found necessary. These plans are submitted and an estimate of the cost of each is made. It may be found necessary to make two or more plans and estimates before the most economical and best plan is obtained. The amounts are then separated according to their respective items as listed below. A separate page giving in detail the estimated cost of each job along with a summary sheet is included under each item.

A file is maintained in which information regarding future budget work is kept. This information is supplied by problems which come up during the current year.

The figures for each item are arrived at as indicated opposite the item number as follows:

Item 1—Assessments. Obtained from the Financial Department and are based on improvements along company property.

Item 2—Land Devoted to Electric Operations. Based on the increased load in certain sections.

Item 3.—Substation Buildings. Estimated from the design of a new substation which was found required as explained in the first part of this article. Miscellaneous additions to substation buildings is a concrete figure carried forward each year.

Item 4—General Structures. Based on estimates for additions and alterations to General Structures as found necessary for repairs and expansion.

The following items, and how their requirements and estimates are obtained, are explained in the first part of this article.

Item 5—Substation Equipment.
Item 6—Underground Conduits.
Item 7—Overhead Conductors, etc.
Item 8—Street Lighting.
Item 9—Transmission.
Item 10—Underground Cables.

Estimates for these items are made from plans made from engineering studies of the system. The following items are estimated from the amounts expended during past years. These figures are obtained from the Accounting Division. A graph is then made with dollars as the ordinate and years as the abscissa and a curve

plotted. The trend of the curve is carried on to the end of the coming year, and the figure opposite the dollar scale is the estimated amount required.

Item 11—Service Cutouts.
Item 12—Line Transformers and Devices.
Item 13—Consumers' Meters.
Item 14—Printometers.
Item 15—Current Transformers.
Item 16—Meter Installations.
Item 17—General Office Equipment.
Item 18—General Stores Equipment.
Item 19—General Shop Equipment.
Item 21—Laboratory Equipment.
Item 22—Miscellaneous Equipment.
Item 23—Engineering and Superintendence.

Item 20—Transportation Equipment. Obtained from the Superintendent of Transportation, who in turn requests the various Division Heads to advise him of any replacements or additions that they may require during the coming year.

Unexpended balances are made up of the amounts approved for the current year and are not entirely used, but will be required to complete jobs during the coming year. This amount is estimated and based on a report of the amount of work done by October 31 and the amount to be done by December 31. These percentages of work done are obtained from the Construction Divisions. Any orders carried over from previous years are listed separately.

From the totals of each separate item, the total amount required for the coming year is obtained. These totals are submitted for approval and their approval automatically authorizes the work to be done the coming year.

Heating Plants Have Difficult Water Problems

Laboratory Conclusions and Operating Results of the Feed Water Treating System of the Beacon St. Central Heating Plant

FEED WATER treatment is of extreme importance in a central heating plant. Recent developments in boiler design and firing methods have made possible great increases in rates of driving with consequent great reduction in investment cost. If any particular method of water treatment allows higher steaming rates, then the cost reduction thus brought about in the entire plant far overbalances any possible increased cost of installing and operating the treating system.

The results of investigation and operation of the Beacon St. heating plant of the Detroit Edison Co. were presented before the annual convention of the American Water Works Assn. in a paper prepared jointly by J. H. Walker and Leo F. Collins of the Detroit Edison Co. and Prof. A. H. White and E. P. Partridge of the University of Michigan. The primary consideration in the selection of the treating system for this plant was that it produces nearly as scale free water as possible. A deposit of scale of even egg-shell thickness in the boiler tubes directly exposed to the clear radiant heat would cause overheating and failure of the tube walls.

Make-up is taken from the city water mains. It is a rather soft water and external treatment has never been considered necessary in existing heating plants operated at lowest steaming rates, although internal treatment with sodium carbonate has been used for several years. Consideration was given to several methods of treatment before the selection of zeolite was finally made. Internal treatment with sodium carbonate was one possibility. It produces, however, large quantities of carbonate sludge in the boilers, does not entirely prevent the formation of silica scales and produces a high caustic alkalinity in the boiler. Tri-sodium sulphate was also considered but it is open to similar objections. Barium salts because of their poisonous nature were ruled out as a matter of public policy, due to the fact that steam is used for cooking purposes.

Hot process lime and soda systems were considered and the choice would have been a conservative decision. To the engineers responsible for the design and operation of the plant, it did not appear that this treatment would invariably produce a scale-free water and that the hot sedimentation tanks, which are a necessary part of such a system, would have been costly and awkward. The plant is designed for an ultimate output of 12,000,000 lb. of steam per hr. at about 90 per cent make-up water.

Zeolite Was Final Selection

Zeolite as finally chosen, is open to the theoretical objection that it does not remove the dissolved solids, but merely converts them into more soluble salts, thus creating high concentration of solids in the boiler and requiring a large amount of blowoff. Another objection is that with a bi-carbonate water such as in Detroit, the sodium bi-carbonate produced by the treatment would ultimately cause a high caustic alkalinity in the boiler.

As a means of preventing scale formation, however, it appeared that the zeolite system would be certain of results and operating experience has confirmed this conclusion. The large amount of blow-down is prevented from being a serious cause of heat loss by the continuous extraction of a small amount of water which is passed through a heat exchanger where the heat is transferred with cooler supply water.

High caustic alkalinity in the boiler resulting from the use of the zeolite system with a water high in bi-carbonates demands consideration of the possibility of embrittlement of the boiler steel. For this reason the plan was adopted of treating the water after it passes through the zeolite bed with a carefully graduated dose of sulphuric acid.

A diagram of the water cycle is shown in Fig. 1. The zeolite tanks are 10 ft. in diameter and 25 ft. long set with their axis horizontal. They are constructed on the upflow principle; the true relative merits of the upflow and the downflow were found to be greatly obscured by commercial considerations, but there seemed to be no fundamental objection to the upflow system. The sulphate is of the green sand type, having a rated exchange value of 3375 gr. per cu. ft.

The zeolite bed is 41 in. thick, and the rate of flow at normal load is 4¼ gal. per min. per sq. ft. of bed area. The total output per tank is 445,000 gal. between regenerations at the rate of 63,600 gal. per hr. normal flow, and with a maximum permissible flow of 75,000 gal. per hr. The brine required for regeneration is supplied to the zeolite tank through a central piping system from a central overhead tank.

Acid Treatment Follows Zeolite Tanks

Water flows to the zeolite tank under the city water pressure. In order to insure a constant rate of flow which is essential in an upflow system regardless of fluctuation of temperature, a Venturi type flow control is used. After leaving the zeolite tank, the water is given

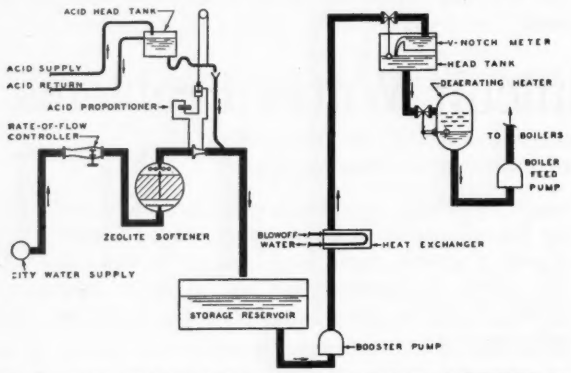


FIG. 1. CITY WATER TREATED WITH ZEOLITE SOFTENER IS USED IN THIS STATION

a dose of acid and then flows into a concrete storage reservoir. Booster pumps lift it to a head tank from which it flows by gravity to the deaerating heater and the boiler feed pumps. The deaerating heater contains a large number of trays over which the water flows and is pumped by a counter charge of steam which removes the dissolved gases quite completely.

Dilute acid is fed by the acid proportioning device in exact proportion to the amount of water treated. Although the water flow is maintained approximately constant by the controller and a fixed rate of acid feed, it was nevertheless felt necessary to adjust the speed exactly and provide an automatic means of cutting off the feed when the flow of water stops. The proportioning device shown in Fig. 2 was therefore developed. Acid is diluted to a 2 or 3 per cent solution in a central tank and pumped through lead lined pipes to a constant level tank in each zeolite softener. Through the bottom of each tank is connected a piece of rubber hose with a small orifice at its end, the elevation of which, with respect to the level of the tank, is controlled by a float resting on a column of mercury. This mercury level is controlled by a Venturi nozzle placed in the water pipe leaving the softener. There are no stuffing boxes required and the float moves up with practically no friction. Since the flow of acid through the orifice and the flow of water through the Venturi float are governed by a square root law, the device gives almost exact proportioning, the only error being caused by the deflection of the lower leg of the mercury U tube, and this is made negligible by the large diameter of this chamber.

Strength of the acid solution is so adjusted as to give the proper feed water condition. At present a 3 per cent solution is used, the ratio of the acid to the boiler water feed being about 33 parts for 100 per cent sulphuric acid per 100,000,000 parts of water.

Blow down amounts to about 4.5 per cent of the total boiler feed but the use of continuous blow down makes possible the extraction of heat from the water and also

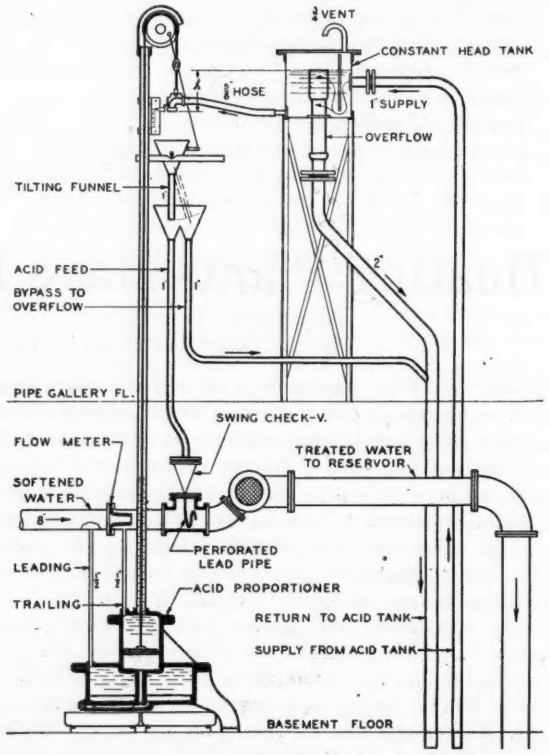


FIG. 2. AN ACID PROPORTIONING DEVICE CONTROLS THE FLOW OF DILUTE ACID IN EXACT PROPORTION TO THE WATER FLOW

gives more uniform steaming conditions than would intermittent blowing off of larger quantities of water.

No Scale Found After Several Months' Operation

The system has been in operation since September, 1926. There have been no tube troubles and no formation of scale in the boilers. The zeolite system produces water with an average hardness of less than three parts per million, this being somewhat better than the manufacturer's guarantee.

Analysis of water in several parts of the cycle is shown in Table I, when using a feed of 33 parts per million of sulphuric acid. With the normal feed of 33 p.p.m. of sulphuric acid, the water going to the boilers is well on the alkaline side, and the acid reacts completely before the water enters the deaerator. These results are somewhat better than those obtained in the laboratory and although farther removal of carbon dioxide could probably be accomplished by steam treatment, it would hardly be justified and is not contemplated.

As an experiment to determine the possibility of further decreasing CO_2 content of the steam, some phos-

phoric acid was used for a short period in addition to the sulphuric acid. The results are shown in Table II. The results indicate that it is entirely possible to control the carbon dioxide content of the steam by varying the acid feed. Although the primary purpose of the acid is the omission of caustic embrittlement, its use also makes it possible to reduce the carbon dioxide content of the resulting steam approximately in proportion to the amount of acid fed.

The zeolite water softening system operates satisfactorily while the acid feed with careful supervision appears to be quite practical and reasonably safe. Continuous blow-down through a heat exchanger is satisfactory and the system of control is effective. Inspection of the boiler after eight months of operation reveals clean tubes and no serious corrosion, and there have been no tube burnouts.

TABLE I. WATER CONDITIONS AT VARIOUS POINTS IN THE CYCLE, ALL FIGURES ARE IN PARTS PER MILLION, THE ACID FEED IN THIS CASE BEING 34 PARTS OF 100 PER CENT SULPHURIC ACID PER MILLION PARTS OF WATER TREATED

	Raw Water	After Zeolite	After Acid Feed	After Deaerator	In Boiler	Steam
Temp. °F.	40.0	40.0	40.0	215.0	365.0	365.0
Pressure lbs. gs.	45.0	7.5	7.5	.....	155.0	155.0
pH value	7.6	8.4	5.8	8.6	.....	5.4
CO_2(free)	1.8	1.8	18.1	0.0	0.0	12.0
O_2 cc per liter	6.03	6.03	6.03	.016	.....	.044
$NaHCO_3$	0.0	116.0	24.2	14.6	0.0	.....
Na_2CO_3	0.0	0.0	0.0	4.1	143.0	.....
Na_2SO_4	0.0	30.0	88.5	77.5	1600.0	.....
NaOH	0.0	0.0	0.0	0.0	70.0	.....
$NaHPO_4$	0.0	0.0	30.0	26.2	0.0	.....
Na_3PO_4	0.0	0.0	0.0	0.0	225.0	.....
Total alkalinity as Na_2CO_3	.....	.....	.....	.....	256.0	.....
Na_2SO_4	.....	.....	.....	.....	6.8	.....
Total alk. as Na_2CO_3						
$\frac{SO_4}{CO_3}$	.....	.....	.....	.....	13.2	.....
$\frac{SO_4}{PO_4}$	.....	.....	.....	.....	7.1	.....

TABLE II. PHOSPHORIC ACID CHANGES CONDITIONS IN VARIOUS PARTS OF THE CYCLE SOMEWHAT. THE ABOVE RESULTS WERE TAKEN WITH AN ACID FEED OF 41 PARTS OF 100 PER CENT SULPHURIC ACID PLUS 24.6 PARTS OF 100 PER CENT PHOSPHORIC ACID PER MILLION PARTS OF WATER TREATED

	Raw Water	After Zeolite	After Acid Feed	After Deaerator	In Boiler	Steam
Temperature °F.	40.0	40.0	40.0	215.0	365.0	365.0
Pressure lbs. gs.	45.0	7.5	.....	.....	155.0	
pH value	7.6	8.6	6.4	8.5	.....	5.4
CO_2(free)	1.8	.....	16.1	0.0	0.0	25.0
O_2 cc per liter	6.03	6.03	6.03	.014	.....	.044
$NaHCO_3$	0.0	120.0	60.5	38.0	.....	.....
Na_2CO_3	0.0	0.0	0.0	14.8	194.0	.....
Na_2SO_4	0.0	30.0	81.0	.....	1500.0	.....
NaOH	0.0	0.0	0.0	0.0	260.0	.....
Total alkalinity as Na_2CO_3	.....	.....	.....	.....	650.0	.....
Na_2SO_4	.....	.....	.....	.....	2.3	.....
Total alk. as Na_2CO_3						
$\frac{SO_4}{CO_3}$	.....	.....	.....	.....	10.0	.....

It has been demonstrated that the use of additional acid in the form of phosphoric acid gives less carbon dioxide in the steam and less caustic alkalinity in the boiler. Necessity of thus reducing the carbon dioxide is not certain and will be justified only if the steam shows itself later to be corrosive with the small amount of acid treating. If scale appears on the tubes when only sulphuric acid is used, we believe that a small amount of phosphoric acid will eliminate it.

THE CLIFFS POWER & LIGHT CO., Ishpeming, Mich., a subsidiary of the Cleveland-Cliffs Iron Co., is reported to be planning a hydroelectric plant on the Escanaba River near Princeton, Mich.

Natural Gas Power Generation in the Southwest

$15,000,000 GAS LINE IN CONSTRUCTION FROM PAMPA, TEXAS, TO WICHITA, KANSAS, TO MAKE ADDITIONAL CHEAP FUEL FROM PANHANDLE AVAILABLE TO KANSAS CITY

NATURAL GAS is one of the cheapest and most costly of fuels for power generation. Paradoxically enough, it can be utilized economically for this purpose only when it exists in comparatively small or comparatively large volumes. When the supply and the demand for domestic purposes balance the year around, natural gas in itself constitutes a source of energy that is far too valuable for profitable conversion into power.

Where it exists in limited volumes—that is, in fair quantities which are, however, insufficient to justify general distribution for domestic purposes—it becomes one of the cheapest fuels. This also holds true in sections such, for example, as Monroe, La., where large supplies of gas suitable for domestic purposes are wasted because the means of distribution are lacking.

In the southwest, natural gas is used generally for domestic purposes but the development of many new fields affording supplies in excess of the peak load demand enables it to compete with other fuel for the generation of power. The supply is also to be further augmented by the completion within the next few months of a gas line making available in many sections of Kansas, Texas and Oklahoma enormous quantities of gas from the Panhandle. Work on this new 250-mile, 20-in. line has been undertaken by the Empire Gas & Fuel Co., a subsidiary of the Cities Service Co. of New York City. When completed it will enable the company to deliver gas from the Panhandle field through its own lines to Kansas City.

This new line, which will represent an investment of about $15,000,000, will tap the eastern part of the Amarillo gas field in Carson, Gray and Wheeler counties, in the Texas Panhandle. It will have a rated capacity of 70,000,000 cu. ft. daily, which will increase the delivery capacity of the Cities Service Gas Co. more than fifty per cent. When additional compressor capacity is installed, the line will be able to carry 97,000,000 cu. ft. daily.

Along the course of the new line, three new compressor stations, having a combined capacity of 9000 hp., are being erected. In addition, a 4000-hp. compressor station is being built at Ottawa, Kans., on the main twin 16-in. lines. At Wichita, Kans., the new 250-mile line from the Panhandle will tie with the present Cities Service system, culminating in two 16-in. lines to Kansas City, which are being interconnected and looped at numerous points to secure flexibility and increased capacity.

Of the 550,000 acres leased by major oil companies in the Panhandle area, it is expected that 267,000 acres will be productive of gas, with a total reserve estimated by engineers at 3,000,000,000,000 cu. ft. at a rock pressure of 430 lb. a sq. in. The new line should make immediately available 300,000,000 cu. ft. of gas a day, with a potential supply of several times that amount. In Oklahoma, the Cities Service Co. has an open flow gas supply of 1,300,000,000 cu. ft. daily connected to its

system supplying Kansas, Missouri and Oklahoma. The average consumer load on the system is about 110,000,000 cu. ft. daily. By going into the Panhandle, the company is making available one of the largest natural gas areas known.

It is planned that, as markets develop in the vicinity of Kansas City, a 130-mi. line from Wichita to Ottawa, Kans., will be opened, which will provide a short line for conveying gas from the Amarillo field into the system terminating at Kansas City.

The Empire Co.'s present peak load in Kansas City is about 32,000,000 cu. ft. daily with about 110,000 domestic consumers connected.

In many sections of the Southwest, natural gas is sold for industrial purposes at prices ranging from 3 cents to 16 cents per 1000 cu. ft. and the economies resulting from the use of this fuel are said to be large, despite the fact that preference is given to domestic users. During the "preference load" in winter, a temporary shut-off does not necessarily offset the cheap rate at which the fuel is obtainable, as more and more plants are being equipped with burners that are suitable for gas, oil or pulverized coal.

With the use of natural gas an efficiency of 65 per cent is commonly obtainable. While it is true that natural gas as fuel necessitates an increase in superheater surface, it makes for economy in operation, in that it tends to decrease labor costs involved in firing and ash removal.

Each year 2500 new gas wells are developed for immediate or future use, and it is thought that there are now 42,000 wells capable of producing commercially valuable quantities of natural gas.

Approximately 66,672 miles of natural gas line are laid in the United States, of which 27,139 miles are in distributing systems in 1933 communities, leaving 39,533 miles of transmission lines. The population served by the 27,139 mi. of distributing systems is in excess of 17,000,000.

Exact invested value of the natural gas industry is not available but if it is assumed that each customer represents investment by the companies of $300 in distribution, transportation and production property, the total is more than $1,000,000,000, exclusive of the value of gasoline recovery plants and carbon black plants.

Within the past two years several major pipe line projects have been constructed. A 14, 16, 18-in. line was built from northwestern Louisiana to Beaumont, Tex. Two 14-in. and 16-in. lines were laid from southern Texas fields to Houston, Tex. A 22-in. line was constructed from Monroe to Baton Rouge, La. and surveys have been completed for ultimate extension to New Orleans. In addition to the 250-mi., 20-in. line now building from the eastern part of the Texas Panhandle to Wichita, Kans., contracts are reported to have been made to supply natural gas to Denver, Colo., which will necessitate the construction of about 400 miles of 22-in. line from the vicinity of Amarillo, Tex.

Considerations in Changing to Powdered Coal

WHEN BEING SUBSTITUTED FOR STOKERS OR HAND FIRING THE SUCCESSFUL OPERATION OF PULVERIZED FUEL BURNING EQUIPMENT DEPENDS TO A LARGE EXTENT UPON THE CONSIDERATION GIVEN TO MAKING THE PROPER INSTALLATION. BY L. C. FESSENDEN*

THERE ARE two general methods employed in burning pulverized coal. That of the bin or storage type and the unit pulverizer. While both types have received much study with many plants of both types in operation, the present tendency seems to be towards the unit pulverizer and the future of burning pulverized coal probably lies in that direction.

By way of information, the bin type consists of large storage bins that hold 10 to 16 hr. supply of powdered coal. This coal is usually pulverized by the day crew in sufficient quantities to last the next 24 hr. Adherents to this system claim a greater accuracy in fuel and air supply and greater ease of control in varying loads. The main drawback is the large initial investment necessary due to the separate pulverizing house and bins required and the necessity of safeguarding against explosions due to large quantity of powdered coal on hand, the expense of maintaining a pulverizing crew and the expense of large heaters for drying the coal.

These points, though not so important in a large installation, make the bin type almost prohibitive in the smaller central station and industrial plant. On account of the low initial cost and adaptability to smaller installations, we find a great many of these plants installing unit type machines, while some of the largest plants now being built are considering the unit pulverizer.

Although it may seem, and is, a simple matter to change from stoker fired boilers to pulverized fuel boilers, some smaller plants have made the change with disastrous results due to the fact that they did not take enough care in selecting their equipment or making proper changes to suit the kind of coal available, the type of load to be carried or other of the many points necessary to consider. The installation must consist of more than a pulverizing mill to feed powdered coal into the old furnaces without changing the setting. Such an installation is a common error of unsuspecting firms purchasing, from an ill-informed or unscrupulous engineer, equipment not suitable for this purpose.

KIND AND MOISTURE CONTENT OF COAL IMPORTANT

There is a direct relation between boiler size, size of pulverizer burner shape and design which must be worked out carefully for each installation. On each unit pulverizer installation it is necessary to obtain the proper fineness of coal, uniformity of feed, low upkeep, low power consumption on motor driven mills, flexibility of coal and air supply with varying loads and a supply of dry coal or means of drying the coal as it is pulverized. The kind of coal to be used in a unit mill must be carefully considered, as the moisture and ash content affect the operation of the unit mill in that certain

*Resident Mgr., Wisconsin Power & Light Co., Sheboygan, Wis. Abstract of paper presented before the Wisconsin Utilities Assn., Madison, Wis., September 2.

coals take more power for pulverizing and certain amounts of moisture and hardness will greatly affect the continuity of feed and life of the wearing parts. If all these points are considered and carefully studied, good results are to be expected, but too great stress cannot be laid on the necessity of thorough study previous to the installation.

In the Sheboygan plant two unit mills are installed in the basement of the boiler room with an auxiliary coal bunker holding approximately 2 t. of coal. Coal from overhead bunkers can be weighed through a weigh larry on its way to the unit mills, permitting records of coal supplied to each unit.

About 20 per cent of the air for combustion is taken through the mills to provide a carrier for the powdered coal, the balance being supplied by the blowers supplying air for the stokers. During the past winter there were times when the moisture in the coal nearly stopped the operation of the pulverizers until further steps were taken to dry it.

Hot Gases from the Furnace Can Be Used Through Mill

Provision has been made in the installation to take part of the heated air from the air-cooled side walls, bridge walls and bottom of the furnace. This, however, proved entirely inadequate, the moisture in the coal running 8 to 15 per cent, so after careful experimenting, gases from the lower part of the furnace were piped into the mills and little or no trouble has been experienced from that source since.

In changing a stoker fired boiler over to pulverized fuel, careful consideration must be given to furnace design and volume with relation to boiler rating it is to carry. In our cases the furnaces were enlarged 50 per cent over the size required for stoker installation with the idea in mind that it would be possible to carry 200 per cent of rating continually and 250 per cent in an emergency.

In actual practice, however, it has been found advisable to operate around 175 per cent as the maximum for continuous operation, high ratings being hard on brick work, especially those portions which are not air cooled. In emergencies we have operated as high as 300 per cent for short periods, but found this furnace maintenance high at this rating.

We expected to have more or less trouble with slagging and on a few occasions before the operators had learned to handle the burners the furnace bottoms did require mining operations to remove slag. Now approximately two wheel barrows of slag is raked out each day and when the boiler is off the line a general cleaning is given to the furnace. There has been no evidence of fly ash, nor have there been deposits in evidence around the plant nor around any surrounding property.

Motor Driven Mills Show Up When Most Needed

One point which was not considered when we put in unit pulverizers causes trouble at times. This is the loss of capacity of pulverizers which occurs in case of system trouble or overloading, pulling the frequency down four or five cycles. The pulverizers, driven by induction motors, lose speed and cut the mill and boiler capacity down when it is most urgently needed. There does not appear to be any remedy for this other than dual drive for each machine which is, of course, expensive, and requires room which is not available.

No trouble has been experienced in getting the fire under the boiler started. A combination oil and gas torch with compressed air has been worked out and a permanent connection installed under the boiler setting. The torch is lighted and inserted, the mill started, and in two or three minutes ignition is started so that the torch can be withdrawn. At present we cannot operate below 125 per cent of rating but it is hoped that changes in the design of the burner, now being contemplated, will remedy this.

A. E. S. C. Tells Year's Progress

Important progress in a dozen major industries is described in the Year Book which has just been issued by the American Engineering Standards Committee, 29 W. 39th St., New York City. An extremely wide range of work is covered, from bolts and nuts to a code for rock dusting coal mines, from specifications for railway ties to standards for methods of recording and compiling accident statistics.

The following table gives a bird's eye view of the status which has been reached in the major lines of work:

Group	Number of projects	Projects approved
Civil Engineering and Building Trades	36	19
Mechanical	61	19
Electrical	39	11
Automotive	4	3
Transportation	10	9
Naval Architecture and Marine Engineering—Shipbuilding	1	..
Ferrous Metallurgy	9	7
Non-Ferrous Metallurgy	14	10
Chemical	12	10
Textile	3	1
Mining	20	5
Wood	5	3
Pulp and paper	2	1
Miscellaneous	22	5
Total	238	103

The number of projects has increased from 212 to 238 and the number of approved standards from 82 to 103 during the year.

There are now approximately two thousand individuals serving on sectional committees, the accredited representatives of over three hundred national cooperating bodies.

The Louisiana Power & Light Co. is erecting new units at its Sterlington Plant, 20 mi. northwest of Monroe, La. Two 35,000-kw. General Electric turbines are to be installed and four 1740-hp. Heine boilers fired with natural gas and operated at 370 lb. pressure. At present this plant has two 15,000-kw. Westinghouse turbines and four 1350-hp. Springfield boilers. Construction and installation are in charge of Ford, Bacon & Davis. The new units will be in operation by May 1, 1928.

Harnischfeger Corp. Makes Low-Cost Power

SIMPLE, COMPLETE RECORDS AND NEW BOILERS WITH WATER-COOLED FURNACES AND AIR PREHEATERS, ARE FEATURES OF LARGE INDUSTRIAL PLANT IN MILWAUKEE

AS AN ILLUSTRATION of what may be done in an industrial power plant to produce steam and power at low cost by using up-to-date equipment, yet without undue elaboration of either apparatus or instruments, performance of a recent boiler addition at the Harnischfeger Corp., Milwaukee, Wis., manufacturer of electric cranes and road building machinery, is of interest. The boiler plant contains four stoker-fired water-tube boilers. Two of these water-tube boilers have recently been installed, with the furnaces water cooled and air preheaters to serve the stokers. Average evaporation with these units is about 10.3 lb. per pound of coal as fired, and average boiler and furnace efficiency is over 80 per cent. The boilers operate continuously at 165 per cent of rating and can go to 225 per cent for a few hours with no trouble.

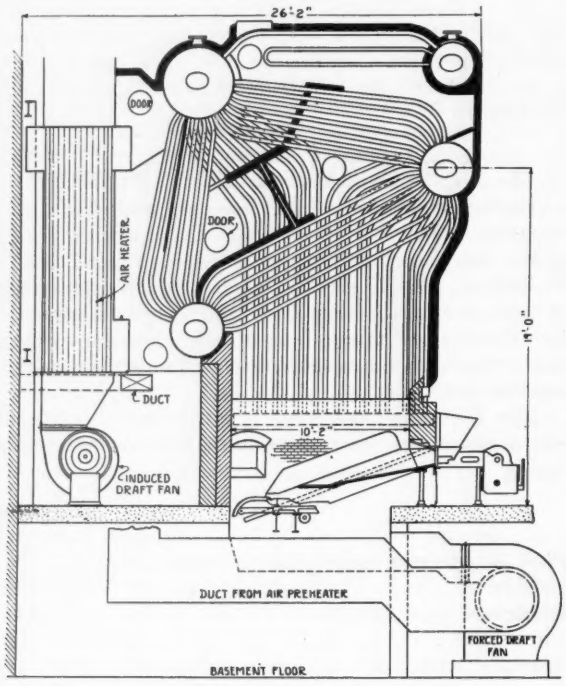


FIG. 1. SECTION THROUGH NO. 4 BOILER

Engine driven generators supply direct current to the industrial departments, in which are also installed a number of forge hammers. These are supplied with about half of the total generated live steam. For 9 mos. of the year all engine exhaust goes to the heating system and the domestic water heaters. According to the plant records, electric power is made for a little over one cent a kilowatt-hour and steam costs approximately 45 cents a thousand pounds, including operating and fixed charges.

Of most interest in the boiler plant are the two new boilers. The other two are of the standard Badenhausen economizer type, each of 300 hp. rating. These are set together and fired by Riley underfeed stokers.

The two new units are also Badenhausen four-drum, water-tube boilers, each rated at 425 hp. These have Badenhausen superheaters and make steam at 160 lb. pressure, 100 deg. superheat. They are also set in battery, Fig. 1 showing a cross-section through the setting and Fig. 4 a front view of the two units. Figure 3 is a side view of the No. 4 unit showing the air preheater. Each boiler is set as shown, the furnace being of refractory up to a line just above the stokers and the front and side walls being water-cooled the rest of the way, as shown. The 3¼-in. water cooling tubes connect to headers at the bottom and at the top are curved to connect with the No. 3 and No. 4 drums of the boiler. The space between the tubes is filled with Plibrico, about 1/5 of the tube surface being left exposed. Water wall surfaces of each boiler is 450 sq. ft.

These furnaces are fired with West Virginia splint burned on Riley four-retort intermediate stokers. These are driven by a P. & H. 5-hp., 235-v., d.c. motor.

Flue gas passes from each boiler to a Badenhausen 3200-sq. ft. tubular air preheater installed just behind each boiler, Figs. 1 and 3. At the bottom of each preheater, a Clarage 18,000-c.f.m. induced draft fan, driven by a 15-hp. d.c. motor, draws the flue gas through

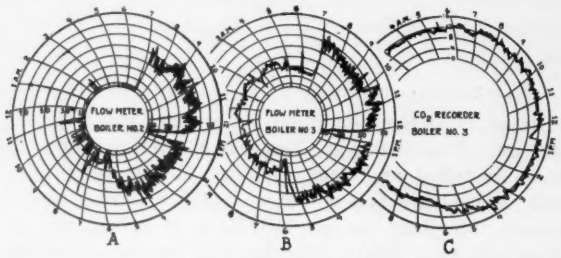


FIG. 2. A—STEAM FLOW FROM NO. 2 BOILER FOR MARCH 16. B—STEAM FLOW FROM NO. 3 BOILER FOR MARCH 16. C—CO_2 AVERAGES 13 PER CENT DURING THE DAY ON BOILER NO. 3

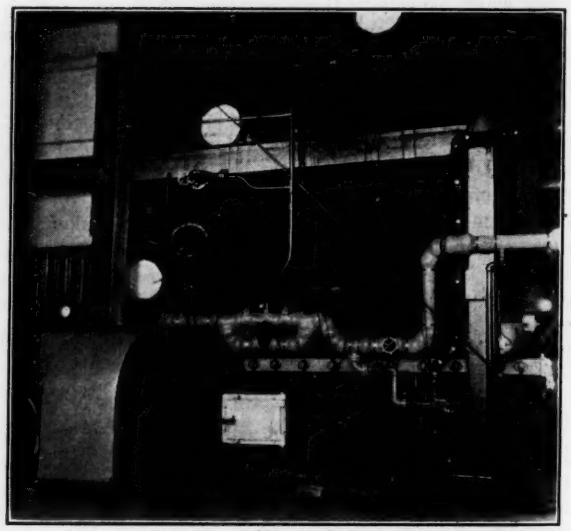


FIG. 3. SIDE VIEW OF BOILER NO. 4, SHOWING AIR PREHEATER AND INDUCED DRAFT FAN AT REAR

and sends it to the stack. Air passes through the tubes of the preheater and flue gas around them; both air and gas each make two passes through the preheater. In the basement below the stokers is a motor-driven Sturtevant 25,000-c.f.m. fan, taking air from the preheater and supplying it to the two stokers. All fan motors are P. & H., 235-v., d.c. machines; a standby 6 by 6-in., 450-r.p.m. Troy engine is provided for the forced draft fans.

Boilers are equipped with Copes feed water regulators, Diamond soot blowers, Reliance water columns, Lunkenheimer and Powell water valves, Crane and Lagonda non-return valves, Yarway, Homestead and Everlasting blowoff valves and Consolidated safety valves. Turner baffles are installed in the boilers.

Coal is weighed in cars as delivered and each stoker has a revolution counter that meters the coal. Water is pumped by air lift from deep wells, softened in a Cochrane, 6000-g.p.h. hot process, lime-soda softener with combined heater and pumped to boilers by two Union outside center packed reciprocating pumps. For emergency feeding, each boiler is furnished with a 2½-in. Metropolitan injector.

In the engine room are installed three Allis-Chalmers engine-driven 235-v., d.c. generators and two steam-driven air compressors. All engines run at 150 r.p.m., take steam at 150 lb. pressure, 75 deg. superheat, and exhaust at 2 lb. gage. One 500-kw. generator is driven by a Nordberg poppet valve engine, one 600-kw. generator by a Nordberg poppet valve uniflow and one 125-kw. machine by an Allis-Chalmers Corliss engine. One air compressor is a 960-c.f.m. Ingersoll-Rand two-stage unit driven by cross-compound steam cylinders and the other is a 260-c.f.m. Ingersoll-Rand, two-stage motor-driven unit.

Results obtained with the new boiler units described above have been extremely satisfactory, in normal daily operation, as well as on test. Complete records of operation are obtained in the boiler room by Republic CO_2 meters, flow meters and pyrometers and American Schaeffer & Budenberg gages and indicating thermometers for steam and other temperatures. Complete tabulations of performance are kept daily, monthly and yearly on the forms shown in Figs. 5 and 6.

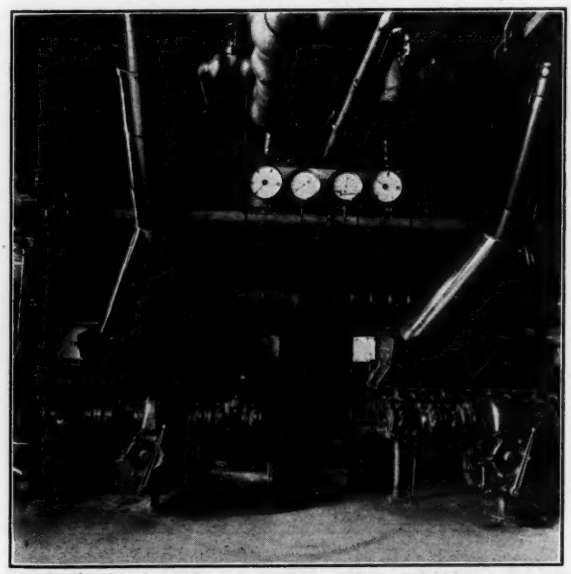


FIG. 4. FRONT VIEW OF THE TWO NEW UNITS, NOS. 3 AND 4

Steam Cost	Del.	¢	K.W.H. Cost	Del.	¢	Compr. Air Cost	Del.	¢
Coal			Cost Steam Used			Cost Steam and Power		
Water			Rep. Mat. and Supplies			Rep. Mat. and Supplies		
Rep. Mat. and Supplies			Labor			Labor		
Labor			Fixed Charges			Cooling Water		
Fixed Charges			Total Expense			Fixed Charges		
Total Expense			K. W. H. Generated			Total Expense		
Steam Generated			Thousand			Air Compressed		
Thousand Lbs.			Cost per K. W. H.			Thousand C. F.		
Cost per 1,000 Lbs.						Cost per 1,000 C. F.		
Well Water Cost			Production Steam Cost			Plant Heating Cost		
Cost Steam and Air			Cost Steam Delivered			Cost Steam Used		
Rep. Mat. and Supplies			Rep. Mat. and Supplies			Rep. Mat. and Supplies		
Labor			Labor			Labor		
Fixed Charges			Fixed Charges			Fixed Charges		
Total Expense			Total Cost			Total Cost		
Water Delivered						Total Building Content		
Thousand Gal.						Thousand C. F.		
Cost per 1,000 Gal.						Cost per 1,000 C. F.		

	Coal Lbs.	Oil Gal. Eng.	Oil Gal. Cyl.	Oil Gal. Air	Lime Lbs.	Soda Lbs.	Sugar Lbs.	Total Expense	Del.	¢
On Hand								Material Purch'd		
Received								Fuel and Supplies Used		
Total								P. and H. Stores Mat. Sup.		
Consumed								Plant Help		
On Hand								Power House Help		
Coal Per K. W. H.								Total		
		Pr. 1,000 K.W.H.	1,000 KWH	1,000 C.F.	1,000 Lbs.	1,000 Lbs.				

FIG. 5. ON THIS FORM THE VARIOUS COSTS ARE DISTRIBUTED EITHER FOR THE MONTH OR FOR THE YEAR

DATE

Coal Fired	BOILERS 1	2	3	4	COAL Total Lbs.	EVAPORATION Total Lbs.	ASHES Total Lbs.	Evaporation Per
Day								
Night								
Total								

	Generators	Engines	AIR COMPRESSORS Motor Drive	Steam Drive	Cool. Water	Air Compressed	WATER SOFTENER			
	K. W. H.	Lbs. Steam	K. W. H.	Lbs. Steam	Gal.	1,000 Cub. Feet	Analysis	Lime	Soda	Grain
Day							H.			
Night							C.			
Total							A.			

	WELL WATER DELIVERY Total Deliv	To Plant	Steam	Air	PLANT HEATING Exh. Steam	Live Steam	Steam	PRODUCTION Live Steam	Temperature
	Gal.	Gal.	Lbs.	Cub. Feet	Lbs.	Lbs.	Total Lbs.	Lbs.	
Day									
Night									
Total									

FIG. 6. QUANTITIES COMPUTED FROM METER READINGS ARE ENTERED ON THIS FORM DAILY

Boilers operate normally at 165 per cent of rating, flue gas leaving the boiler at 550 deg. and leaving the air preheater at 350 deg. This drop heats the stoker air to about 275 deg. Boiler feed water is of 25-30 gr. hardness as it comes from the deep wells, but the softening process reduces this to 1—1.5 gr. and it is always kept heated to 210 deg. by the feed water heater.

In a test run on No. 4 boiler—one of the new ones—by Chas. A. Cahill & Sons, consulting engineers, it was found that at 192.6 per cent of rating for 9 hr. the efficiency of boiler, superheater, air heater, furnace and grate was 84.16 per cent, based on the fuel of 13,101 B.t.u. per lb. as fired.

This fuel contained 8.3 per cent moisture, 6 per cent ash, and 1.16 per cent sulphur (dry basis). Average CO_2 was 13.2 per cent. Actual evaporation per pound of fuel as fired was 10.32 lb., equivalent evaporation 11.38 lb.

Design of the power plant was executed entirely by Charles Dick, chief engineer of the Harnischfeger Corp., who also supervised its erection.

Hydro Turbine Tests—Pitot and Venturi Tubes

MULTIPLE PITOT TUBE METHOD OFFERS MANY ADVANTAGES OVER SINGLE TUBE WHILE THE VENTURI IS THE ONLY TEST METHOD GIVING A CONTINUOUS RECORD OF THE FLOW

IN EARLY technical literature the weir, current meter Pitot tube and later the Venturi tube held prominent places. They are still important for some uses, although other devices and methods developed recently appear to have advantages for special cases, particularly in the power plant field.

For wheels set in open pits the current meter or weir can be used. When the hydraulic units were tested for the Government project at Wilson Dam, bonus and penalty clauses in the turbine contracts were based on weir tests. Due to the high cost, decrease in head, drowning out and other inherent disadvantages common to any large installation, this method of testing was later abandoned.[1] Current meters, if accurately calibrated and properly used in channels of uniform and known cross sections, give reliable results and are frequently used.

Pitot tubes, too, have their field and, although when used singly their application and resulting calculations are sometimes tedious, a new application known as the "Multiple Pitot and Piezometer Tube Method" for measuring the flow of water in closed circuits has been developed and put into service by D. W. Proebstel of the Portland Electric Power Co.

Test curves of the Pelton turbine of the Oak Grove Station of the above-mentioned company are shown in Fig. 1. This is a vertical unit rated at 35,000 hp. under an effective head of 849 ft. and drives a General Electric 60-cycle, 3-phase, 11,000-v., 85 per cent power factor, 30,000-kv.a. generator at 514 r.p.m. Test points were taken at 11 gate openings ranging from 0.15 to 0.8 as measured on the governor index gage.

Tests were completed in 230 min. or an average of about 21 min. for each gate opening. Including a 1300-ft. penstock, the pipe line is 37,000 ft. long, so that after changing the load on the turbine it was necessary to wait a considerable time until conditions in the pipe line became constant. The Pitot tube apparatus was located about 20,000 ft. from the power house in a section of 9-ft. pipe. Communication between the test crews was carried on by telephone.

In addition to the regular turbine crew who handled the turbine, five observers were required, one at the electrical instrument, one at the tailrace, one at the Johnson valve and two at the Pitot tube apparatus.

Construction of the Pitot tube apparatus is shown in Figs. 2 and 3. Instead of a single nozzle, 20 are used and these 20 are equally divided on two cross arms placed at right angles to each other and to the axis of the pipe. The four center tubes are placed at the centers of four quadrants, while the remaining 16 are placed at the centers of equal area segments of concentric rings. In addition to the 20 tubes there are three piezometer openings to give the static head. All 23 openings are connected by brass tubing with glass tubes which are in turn connected to a manifold at the top.

This manifold allows compressed air to be used on top of the water so as to bring the water columns in the tubes down to where they can be read on the scale. Coloring the water with red pigment increases the accuracy and ease of observation.

CAMERA USED TO GET INSTANTANEOUS READINGS

Instantaneous readings are taken by means of a camera as shown in Fig. 4, assuring simultaneous readings and eliminating personal errors and wrong notations. Figure 5 is a close up of the board at 0.25 gate opening. The three piezometer openings are at the right and the height of the other water columns above them are in effect the curves of the velocity distribution along the two diameters of the pipe line. The average velocity

[1] See "Results of Efficiency Tests at Wilson Dam," by L. B. Fagan, page 832, Aug. 1, 1927 issue.

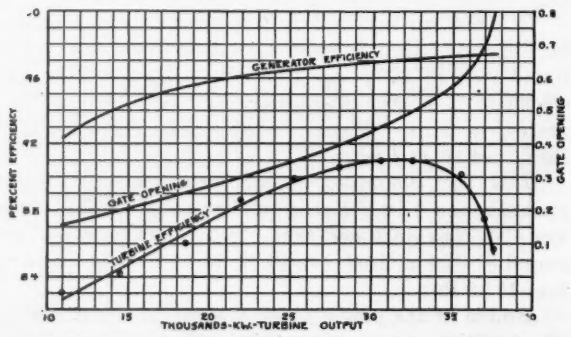


FIG. 1. TEST RESULTS OF THE OAK GROVE PLANT AS DETERMINED BY THE MULTIPLE PITOT TUBE METHOD

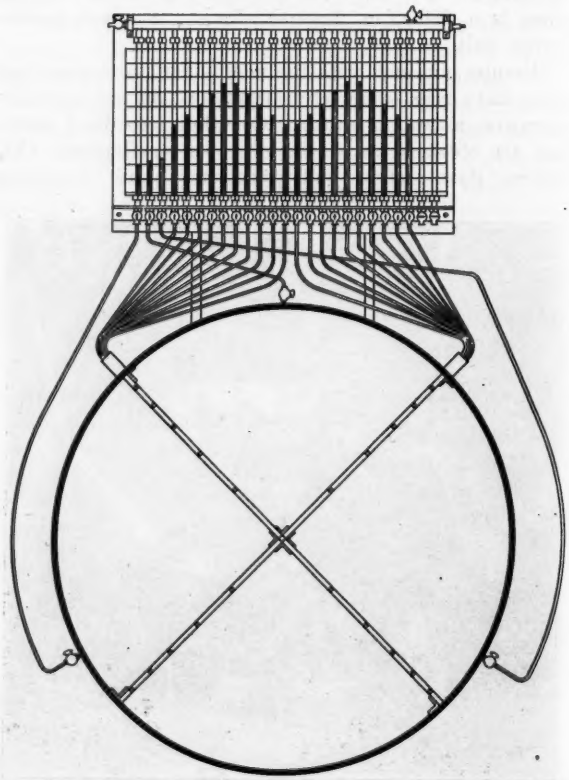


FIG. 2. TWENTY PITOT TUBES ON TWO DIAMETERS ARE UTILIZED

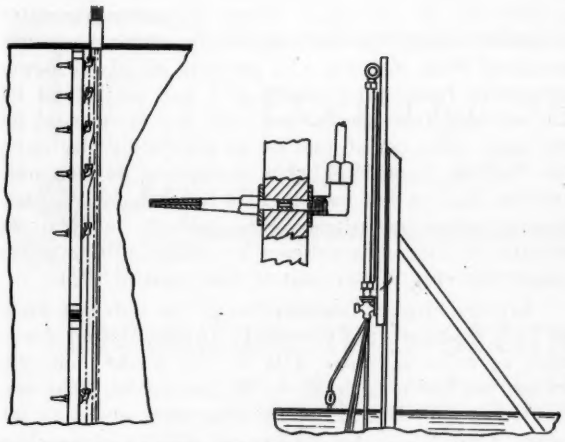


FIG. 3. EACH TUBE IS CONNECTED TO A GLASS TUBE BY MEANS OF BRASS TUBING

head is the average of the various water column readings above the average piezometer tube readings.

From this the quantity in cubic feet per second can be found by combining the two equations, $v = k\sqrt{2gh}$ and $Q = av$, where v = velocity in ft. per sec., k = Pitot tube constant, $g = 32.2$ and Q = quantity in cu. ft. per sec., and a = area in sq. ft.

The coefficient k of the tube should not be neglected. The A. S. M. E. code states that the average coefficient should be 0.98 but Mr. Proebstel maintains that an average value should not apply throughout the entire range where the velocity may vary from 1 to 9 ft. per sec. In his tests he assumed that the coefficient varies uniformly from 0.976 at 2 ft. per sec. to 0.991 at 7 ft. per sec. Ultimate development of this method will call for further research in order to determine more accurate coefficients to apply to present day pipe line usage.

Venturi Tube Gives Continuous Record

In many cases it is desirable to have a continuous record of the water flow through a turbine. These records are of value to the load dispatcher, to the operator and to the supervising engineer. If properly analyzed each day they give valuable information and data regarding plant operation.

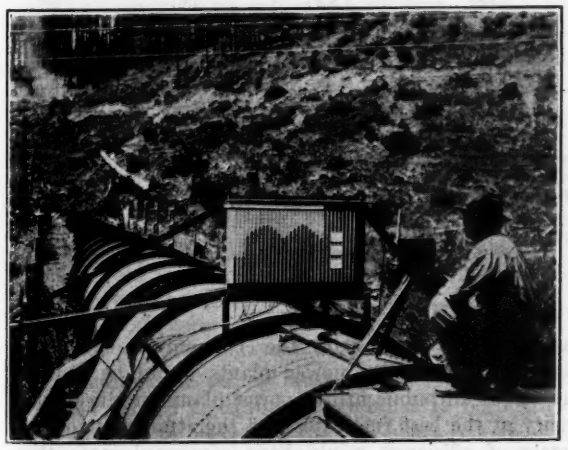


FIG. 4. SIMULTANEOUS READINGS OF ALL TUBES ARE TAKEN BY MEANS OF A CAMERA

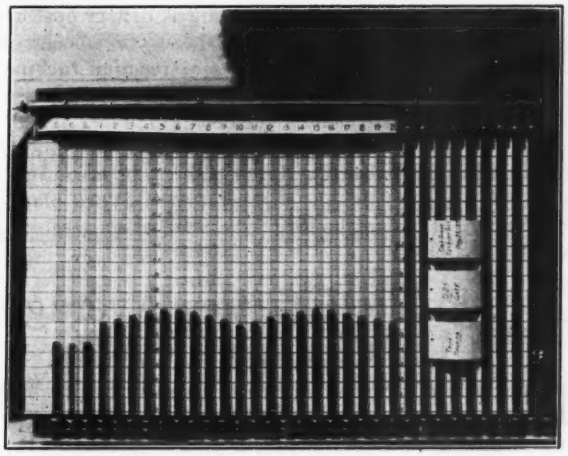


FIG. 5. A CLOSE UP OF THE BOARD TAKEN AT 0.25 GATE OPENING. (THE THREE PIEZOMETER TUBES ARE SHOWN AT THE LEFT. NOTE DIFFERENCE IN READING BETWEEN THIS GATE OPENING AND THAT SHOWN IN FIG. 4 FOR 0.6 GATE OPENING)

Two types of Venturi tubes and method of installing and centering them in existing pipe lines are shown in Fig. 6. The tubes should be installed as close to the power plant as it is possible and still have a straight run of pipe of sufficient length. Connections of the recording instruments should be large enough to transmit the pressure changes without lag or sluggishness, air pockets must be avoided and in cold climates the pipes must be protected against freezing.

The principle of operation of Venturi tubes is too well known to need a detailed description. The theory is based on Bernoulli's theorem that, neglecting friction losses, the total energy of the water is the same in all cross sections of a horizontal pipe. By decreasing the cross section of the pipe at the throat of the tube the velocity is increased with the corresponding drop in pressure. The quantity of water flowing through the tube is a function of the pressure differential between the entrance and the throat of the tube and this pressure differential is used either as a means of computing the flow in single tests or as a method of actuating the recording mechanism for continuous records.

By means of comparative standards obtained from

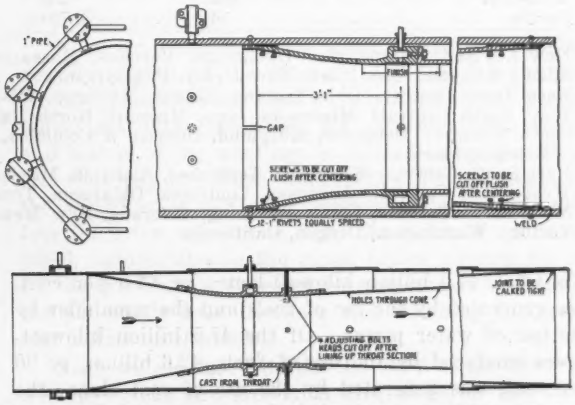

1" PIPE
FINISH
GAP
SCREWS TO BE CUT OFF FLUSH AFTER CENTERING
SCREWS TO BE CUT OFF FLUSH AFTER CENTERING
WELD
HOLES THROUGH CONE
JOINT TO BE CALKED TIGHT
ADJUSTING BOLTS HEADS CUT OFF AFTER LINING UP THROAT SECTION
CAST IRON THROAT

FIG. 6. TWO METHODS OF INSULATING VENTURI TUBES IN EXISTING PIPE LINES

several hours operation when the plant is new or operating under satisfactory conditions, losses in efficiency, due to wear in seal rings or blades of reaction turbine or wear in nozzles, needles and buckets of impulse wheels can be detected and remedied.

In other words, the Venturi tube offers a convenient and accurate method of obtaining a single or a continuous test and is a valuable adjunct to the hydro plant, even though it cannot be strictly classed as an essential piece of equipment.

U. S. Public Utilities Average 1.94 Lb. Coal per Kw-Hr.

TOTAL AMOUNT of electricity produced at public utility power plants in 1926 was 73,791,000,000 kw-hr., according to a statement just made public by the Geological Survey of the Department of the Interior. Of this total, 47.5 billion kilowatt-hours, or 64.5 per cent, was generated by the use of fuels and the remainder by the use of water power. Of the 47.5 billion kilowatt-hours produced by the use of fuels, 42.6 billion, or 90 per cent, was generated by the use of coal alone; the remaining 10 per cent of fuel-power output was generated by the use of fuel oil, gas and wood. Coal is thus by far the chief source of power generated at public utility power plants. In 1926 the power produced from coal was 57.7 per cent of all the power generated, from water power 35.5 per cent, from oil 3.1 per cent, from gas 3.3 per cent, and from wood 0.4 per cent. The use of fuel oil in generating electricity has declined since 1924 when it reached its maximum and less fuel oil was used in 1926 for this purpose than in any other year since 1918. Indeed, in 1926 the amount of fuel oil consumed by public utility power plants was only 57 per cent of that used in 1924.

Average rates of consumption of the different kinds of fuel in generating electricity in the United States were as follows: Coal, 1.94 lb. per kw-hr.; oil, 243 kw-hr. per barrel; gas, 22 cu. ft. per kw-hr. The best fuel rates for these different fuels were about as follows: Coal, 0.9 lb. per kw-hr.; oil, 450 kw-hr. per barrel; gas, 13 cu. ft. per kw-hr. As these are roughly one-half the average rates, the consumption of fuel by electric public utility power plants would be reduced one-half if all public utility power plants produced electricity at the best fuel rates and the attainment of this degree of efficiency would have conserved more than 20,000,000 t. of coal in 1926, representing a value of about $75,000,000.

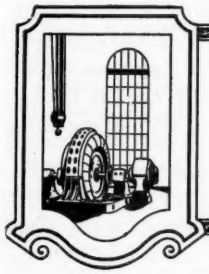
PRODUCTION OF ELECTRICITY AT PUBLIC UTILITY POWER PLANTS IN THE UNITED STATES BY THE USE OF FUELS IN 1926

	(Millions of Kilowatt-Hours)							By fuel power					
		By water power				Coal		Oil		Gas		Wood	
	Total	Quantity	Per cent of total	Total	Per cent of total	Quantity	Per cent of total fuel power	Quantity	Per cent of total fuel power	Quantity	Per cent of total fuel power	Quantity	Per cent of total fuel power
United States	73,791	26,189	35.5	47,602	64.5	42,589	89.5	2,280	4.8	2,405	5.0	328	0.7
New England	5,166	1,685	32.6	3,481	67.4	3,205	92.1	276	7.9	0	0	0	0
Middle Atlantic	20,527	6,050	29.5	14,477	70.5	14,397	99.3	74	.5	6	.1	0	0
East North Central	17,664	2,069	11.7	15,595	88.3	15,367	98.5	14	.1	212	1.4	2	0
West North Central	4,587	1,516	33.0	3,071	67.0	2,595	84.5	195	6.3	269	8.8	12	.4
South Atlantic	7,197	2,087	29.0	5,110	71.0	4,570	89.4	529	10.4	4	.1	7	.1
East South Central	3,049	1,925	63.2	1,124	36.8	1,108	98.6	14	1.2	0	0	2	.2
West South Central	2,639	48	1.9	2,591	98.1	822	31.7	452	17.4	1,310	50.6	7	.3
Mountain	3,425	2,834	82.7	591	17.3	517	87.5	59	10.0	3	.5	12	2.0
Pacific	9,537	7,975	83.6	1,562	16.4	8	.5	667	42.7	601	38.4	286	18.4

CONSUMPTION OF FUELS BY PUBLIC-UTILITY POWER PLANTS IN THE PRODUCTION OF ELECTRICITY IN 1926

	Fuel consumption (thousands)			Fuel rates		
	Coal (net tons)	Oil (barrels)	Gas (M cubic feet)	Pounds of coal per kilowatt-hour	Kilowatt-hours per barrel of oil	Cubic feet of gas per kilowatt-hour
United States	41,310	9,399	53,168	1.94	243	22
New England	2,787	921	0	1.74	300	..
Middle Atlantic	12,754	352	148	1.76	210	22
East North Central	15,025	48	5,080	1.95	300	24
West North Central	3,573	974	5,917	2.86	200	22
South Atlantic	4,178	2,299	157	1.83	230	37
East South Central	1,335	63	...	2.41	230	..
West South Central	962	1,777	31,338	2.34	254	24
Mountain	682	265	161	2.64	224	56
Pacific	14	2,701	10,367	3.30	247	17

New England: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut.
Middle Atlantic: New York, New Jersey, Pennsylvania.
East North Central: Ohio, Indiana, Illinois, Michigan, Wisconsin.
West North Central: Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas.
South Atlantic: Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida.
East South Central: Kentucky, Tennessee, Alabama, Mississippi.
West South Central: Arkansas, Louisiana, Oklahoma, Texas.
Mountain: Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada.
Pacific: Washington, Oregon, California.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Procedure in Starting Up a New Generator

PART I. MECHANICAL AND ELECTRICAL INSPECTION OF A NEWLY INSTALLED MACHINE PREPARATORY TO STARTING IT UP. BY MARIN PHILLIPS

WHEN INSTALLING electrical generating equipment the man in charge of the work has two separate duties to perform.

First, the equipment must be installed according to plans and specifications which should conform with the latest and best methods of doing the work, taking into consideration points relating to safety, foundation construction and size and kind of wire used for the installation. As clean and dry a location as it is possible to obtain should be selected for the installation so as to eliminate operating trouble when the work is completed.

Second, the next important duty after the above conditions are fulfilled and the generator installed and ready to be started up is to see that a thorough inspection is made of the machine so that it is really ready to run when started.

Most likely every operating electrician who follows the game will sooner or later be called upon to start up a newly installed generator all by himself. It will not be out of the ordinary for the new man to feel nervous about undertaking the job for the first time, in fact, if he is interested in his job he is bound to be nervous and anxious for the work to come out in good shape.

If the new man knows the procedure and does not overlook anything, he will have more confidence in himself and everything will turn out successfully.

The procedure outlined in this article is based on practical experience and methods in use today.

As an example, we will take a 300-kv.a., 2300-v. horizontal driven generator, direct connected or belted to the prime mover, all construction work and wiring being completed and the generator ready to turn over under power.

There is nothing that can help the new inexperienced man more than being well acquainted with the installation and the best way to gain this knowledge is to make a thorough inspection regarding the general condition of the machine and the wiring. Let us divide this inspection into two parts; call part one the "mechanical" and part two the "electrical" inspection.

MECHANICAL INSPECTION

A number of things must be determined. Is the machine leveled up properly and has it been turned over by hand to make sure that the shaft is well in line with the bearings and turns freely? Are all bolts and nuts tight? Foundation and other important bolts should be provided with lock nuts or some other means of locking them so that they can not work loose. Next, look around in the windings and field poles for nails, bolts, nuts and other foreign matter that is always plentiful during the installation of the machine. If the machine is an old one and has been standing idle for any length of time, it is just as important to make this inspection. When a generator has been left standing idle, it serves as an excellent receptacle and dumping ground for all kinds of refuse accumulating around the plant, such as old clothes, oil cans, pails, bottles, worn out tools and a multitude of other loose articles. Too much time cannot be given the generator in the way of inspection, and noting that the work is well done. There are so many little things that need attention just before starting up that there is a tendency to overlook some of them and pick out the ones that seem the most important. This should not be done. One may get away with a halfway inspection several times, and then start up one more generator and wreck it due to a careless inspection. The field pole connections and the field pole leads going to the slip rings are another important thing to inspect if the machine is an old one. If any of these connections come loose, they are apt to damage the field pole winding or the stator winding. To some this will seem like being too particular or fussy, but when you stop to think that a nail or bolt lodged in the rotor member some place may cause a damaged winding that will cost several thousand dollars to replace, then it doesn't seem so out of place to be fussy and particular with the inspection. Everyone always feels relieved and proud of the installation if it starts properly with no serious trouble.

Next, we will examine the machine stands for cleanliness by wiping off the dust and dirt that has accumulated. If possible the machine windings should be well blown out with compressed air, blowing from the top and bottom of the windings, so as to dislodge any chips, etc., that may be hidden from sight. When blowing out the windings, it is a good practice to let the air blow free for a few minutes to clean the moisture and water which accumulates in the pipes, before putting the air on the windings. This can be ascertained by holding the air nozzle near the floor and watching the water accumulate on the floor.

Next, we can look into the condition of the bearings. Are they clean and free from dirt, chips, or any other foreign material? Are the oil rings loose and do they turn freely? Look them over carefully to see that they

have not been sprung or bent out of round, which would keep them from turning when the shaft revolves. If the generator is an old one and has not been in operation for some time, pay particular attention to the oil grooves which are cut in the babbit for distributing oil through the bearings, as they may be filled up and need cleaning out. The oil grooves cut around each end of the bearing in the babbit should be cleaned out, since, if they become filled up, the oil will follow the shaft out of the bearings and get into the windings. The top bearing cap will have to be taken off and the bearing removed to make this examination. After it is assured that the bearings are clean and in good shape put the top back in place and clean off the surface between the top and bottom part of bearing cap to insure a good even fit. This is essential in order to prevent the oil from leaking out through the joint. It will make a tighter joint if a thin coat of white lead is applied to the surfaces and then pull the bearing cap bolts up tight.

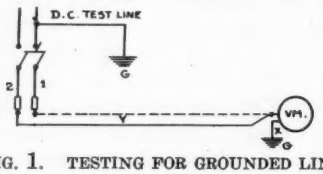


FIG. 1. TESTING FOR GROUNDED LINE

The bearings can now be filled to the proper level with oil. Run the machine for a week or two and then draw off the oil and flush out the bearings with kerosene or gasoline. This is important on a new machine as there will be a certain amount of sludge in the bearings caused by the shaft wearing a smooth fit into the babbit. There is apt to be some sand left in blow holes and chips from machinery and rough places in the casting.

There are so many different grades of oil to choose from that it is difficult to say which kind to use. However, it can be said that nothing but the best grade of oil should be used. If unable to decide on the grade or kind of oil to use call in one of the oil company's representatives. The lubricating problem of today has developed into one of science and the oil companies have made careful studies of the machinery applications and are prepared to furnish the best oil for the operating condition in question.

After this first change of oil the length of time that the machine can operate satisfactorily before it is changed again will depend on the operating conditions and surroundings, such as the high or low speed of the shaft, the pounds pull per square inch of bearing surface, wear of the bearings, operating temperature of the bearings, the amount of dirt and dust in the air or the life of the oil, which will depend on the grade and whether it was properly selected to suit the operating conditions. The steady operation of the generator depends on the bearings, whose life is determined by the way they are oiled. Some system and careful inspection should be in force, so that a close watch can be kept on the condition of the oil in the bearings of all the generators in the plant, so that it can be changed at regular intervals when it starts to deteriorate or lose its oiling qualities. It is unnecessary to be economical with the changing of the oil in the generator bearings, as there are several places in the plant such as line shafts and other machinery where the oil that has been in use in the generator bearings for several months will lubricate just as well as the new oil. If this procedure is followed, the generator bearings will remain in good condition which is an asset for long continuous operation.

Electrical Inspection and Tests

When a new generator is received it has been shipped probably on a flat car, which exposes it to the weather. The manufacturer, however, always covers it well and endeavors to have it reach the customer in good condition. But it may have been on the road and standing around for several weeks, during which time its electrical resistance may have been lowered, due to moisture getting into the windings.

An old generator that has been standing idle for a considerable period may also have absorbed more or less moisture in its windings. The amount of moisture accumulated in the windings can be determined only by a careful measurement of the resistance of the winding insulation to ground.

There are two methods most generally used when measuring the insulation resistance of electrical apparatus. One is the megger method that measures the resistance and can be read directly in ohms. The other is the direct current voltmeter method and the resistance in ohms will have to be calculated from the readings obtained with the voltmeter. Not everybody is fortunate enough to have a megger testing set and will have to fall back on the old method. The only apparatus needed will be a direct current voltmeter and a direct current source of power from a battery or power line.

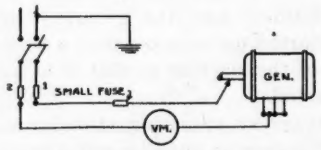


FIG. 2. INSULATION TEST OF STATOR WINDINGS

Before starting the test, the direct current source of power must be tested for grounds or partial grounds, which may be tested with a lamp or the voltmeter. It is safer to use the voltmeter as the lamp bank will fail to show a partial ground unless it is sufficient to make the lamps glow.

Figure 1 gives an illustration on how to test the circuit for grounds before starting to test the generator's insulation resistance to ground. Connect one terminal of the voltmeter by lead X to ground as shown at G, and then touch the other terminal lead Y first to line terminal 1 and then to line terminal 2. At each test watch the voltmeter closely to see what it reads. Suppose that it did not read anything when the terminal Y was touched to line leads 1 and 2, then this would indicate that the direct current source was free from grounds. But suppose that when the terminal lead Y was touched to line lead 1, the voltmeter did not read any volts, but when it was touched to line lead 2 that it read practically full line voltage. This would indicate that line 1 was grounded and that this is the line that must be connected to the generator frame while making the insulation test, and the other line will have the voltmeter connected into it. A small fuse of 5 or

10 amp. should be connected into the grounded line between the switch and generator frame as a safety precaution.

Figure 2 shows the proper way to make the connections for measuring the insulation resistance to ground of the stator winding by connecting the grounded lead to the frame and touching the other lead to the generator terminals. Figure 3 shows the connections for measuring the insulation resistance to ground of the field poles by connecting the grounded load to the shaft and touching the other lead to the slip rings on the shaft.

It is absolutely necessary that one side of the direct current test circuit be free from grounds, otherwise misleading results will be obtained. Suppose that the voltmeter was connected into test lead 1 and then from the other side of the voltmeter to the winding and that test lead 2 was then connected to the frame of the generator.

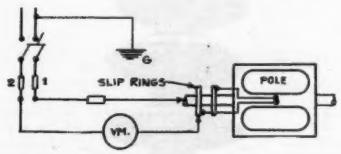


FIG. 3. METHOD OF TESTING FIELD POLE INSULATION RESISTANCE

Then if there was much of a ground on lead 1, a short circuit would be created that would most likely blow the fuse, as the generator frame is grounded and there will be a path for the current to flow from line 2 through the generator frame to ground and back to the ground on line 1. If the ground on line 1 was small it would not blow the fuse but it would cause the insulation resistance to be measured wrong, as we would be measuring the resistance of the ground on the test circuit in parallel with the resistance to ground of the generator winding and as the ground resistance on the test circuit would not be known, the insulation resistance calculated for the generator winding to ground would be useless. The formula for measuring the electrical insulation resistance of generator, motor windings, transformers, etc., is as follows:

$$R = \frac{R^1(V - V^1)}{V^1}$$

in which R = the resistance to ground or between wires, R^1 = the total resistance of the voltmeter, that is, all internal and external resistances that would have to be used with the voltmeter to measure the voltage, V = voltage of direct current test circuit, and V^1 = voltage registered by the voltmeter with the connection as shown in Fig. 2.

The following sections on insulation resistance are taken from the standards of the American Institute of Electrical Engineers:

Section 2380, General—The insulation resistance test shall be made with all circuits of equal voltage above ground connected together. Circuits or groups of circuits of different voltages above ground shall be tested separately.

Section 2381, Voltage for Insulation Resistance Test.—Insulation resistance tests shall, if possible, be made at a d.c. pressure of 500 v. Since the insulation resistance varies with the pressure, it is necessary that if a pressure other than 500 v. is to be employed in any case, this other pressure shall be clearly specified.

Section 2382, Minimum Values.—The insulation resistance of a machine at its operating temperature shall be not less than that given by the following formula:

$$\text{Insulation Resistance in Megohms} = \frac{\text{Volt'ge at term'als}}{\text{rat. in kv.a.} + 1000}$$

The formula applies only to dry apparatus. Such high values are not attainable in oil-immersed apparatus.

Before making the test, the windings, if old, must be well cleaned for if they are oil soaked, mixed with copper or carbon dust, they will show a low resistance to ground. As an example on how to measure and figure the insulation resistance we will calculate the maximum voltage that the voltmeter must read in order that the generator windings insulation resistance may be up to the maximum value.

The insulation resistance in megohms =

$$\frac{\text{Voltage at terminals}}{\text{Rating in kv.a.} + 1000}$$

$$\text{or } \frac{2300}{300 + 1000} = \frac{2300}{1300} = 1.77 \text{ megohms}$$

(One megohm = 1,000,000 ohms.)

Then $R = \frac{R^1(V - V^1)}{V^1}$. Let R^1 = 3000 ohms, V = 500, and R = 1.77 or 1,770,000. Substituting to find V^1, we have $RV^1 = R^1(V - V^1)$ or $1{,}770{,}000V^1 = 3000\ (500 - V^1) = 1{,}770{,}000V^1 = 1{,}500{,}000 - 3000V^1$ and $1{,}770{,}000V^1 + 3000V^1 = 1{,}500{,}000$.

$$V^1 = \frac{1{,}500{,}000}{1{,}773{,}000} = .84 \text{ v.}$$

With the connections as shown in Fig. 2 the voltmeter must read .84 volts in order that the insulation resistance of the winding equal 1.77 megohms. That is assuming that the voltmeter itself has a resistance of 3000 ohms and the d.c. test circuit has a voltage of 500.

As another example, suppose that the voltmeter reads two volts when connected as shown in Fig. 2. Then the resistance in ohms of the generator winding equals

$$R = \frac{3000(500 - 2)}{2} = \frac{3000 \times 498}{2} = 747{,}000 \text{ ohms,}$$

which is less than one megohm, indicating that the windings have absorbed moisture enough to lower the insulation resistance below the safe standard. It must be brought up to a safe value before building up the voltage to put the generator in service, by drying out the windings.

The drying out of generator windings is a matter of considerable importance and will be discussed at length in the next article of this series.

ACCORDING TO A REPORT of the Geological Survey of the Department of the Interior recently issued, public-utility power plants in the United States for July, 1927, produced a total of 6,448,416,000 kw-hr. Of this amount 4,014,313,000 were produced by fuels and 2,434,103,000 by water power. Total output shows an increase of 8 per cent over that for July, 1926.

Recent Studies of Transmission Line Operation*

INVESTIGATION OF OPERATION ON 140,000-V. SYSTEM DISCLOSES VALUABLE DATA ON PROPER METHODS OF CONSTRUCTION. BY J. G. HEMSTREET†

TO DESIGN an insulation system for high voltage transmission lines that will be immune from failure during lightning storms or other abnormal conditions, is one of the most important problems confronting the transmission engineer at the present time.

The experience of those who have been operating some of the larger systems should be of assistance in designing other systems and it is with this thought in mind that the data in this paper is presented. It relates

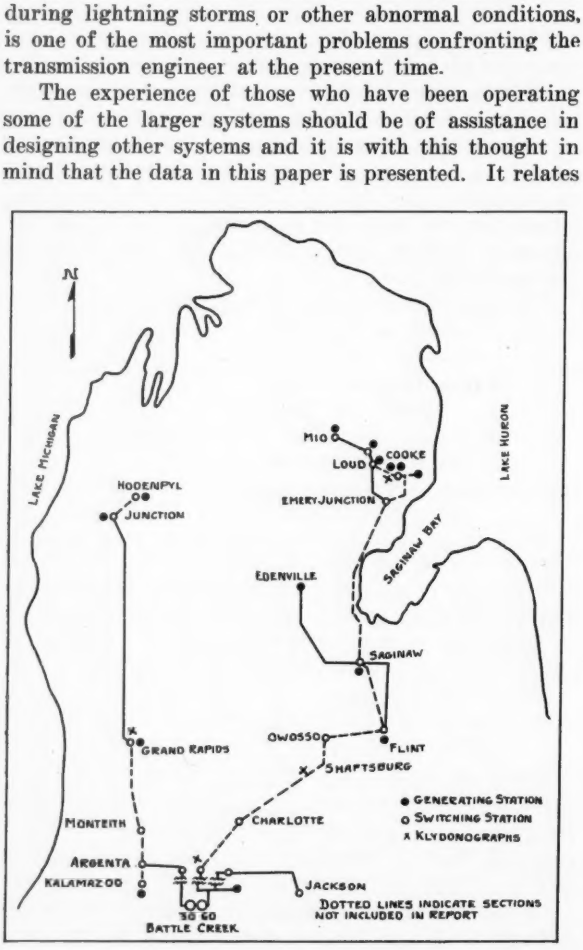


FIG. 1. MAP OF SYSTEM UPON WHICH INVESTIGATIONS WERE CONDUCTED

some experiences and the results of investigation of transmission line operation with particular reference to insulator flashover on the 140,000-v. system of the Consumers Power Co. in Michigan. A map of this system is shown in Fig. 1.

As the system increased in size a few years ago the matter of insulator flashover became of some concern. The earlier lines were not equipped with any form of arc protection but in 1920 standard 15-in. arcing horns, shown by Fig. 2, were installed on the Argenta-Battle Creek section which was added to the system at that time. Later in the year the Jackson-Battle Creek section was added and was also equipped with the standard arcing horn. The Edenville-Saginaw-Flint sections were added in 1924. At the time these last two sections were being designed, there was considerable discussion as to the nature of the transients set up in high voltage systems that caused flashover, and based upon the theory that the trouble was due to rather sustained high frequency conditions, started by the original lightning discharge or some other cause, the insulator flux control

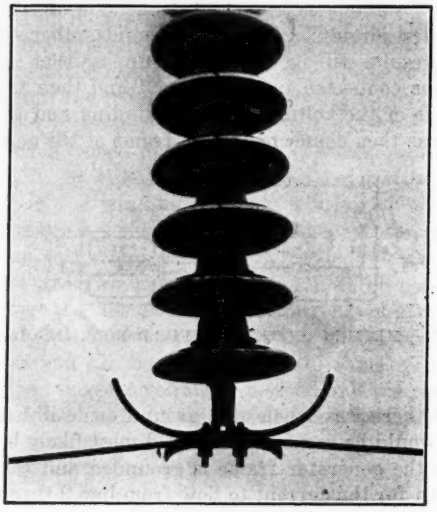


FIG. 2. TYPE OF ARCING HORN USED

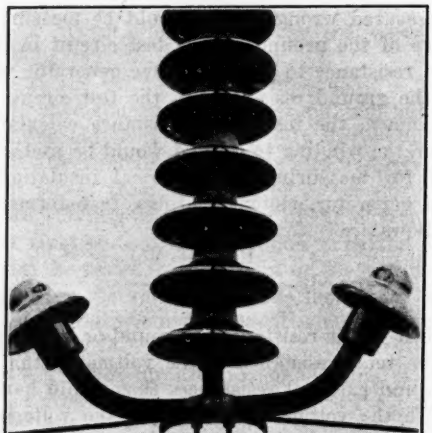


FIG. 3. FLUX CONTROL ASSEMBLY

was offered as a means of raising the flashover voltage of the insulator. These last two sections of line were equipped with the flux control as shown by Fig. 3. The development of the klydonograph offered a means of determining the nature of the transients and four of these instruments were in service during 1925.

At the close of the 1925 lightning season it was decided to make a careful inspection of the two sections of the transmission line added to the system during

*Abstract of a paper presented at the Summer Convention of the American Institute of Electrical Engineers.

†Consumers Power Co.

1924. There had been no failures directly traceable to these sections but it was thought desirable to determine the exact conditions. Later the inspection was extended to other parts of the system.

Results of Inspection and Investigation

Laboratory measurements by Peek indicate that the voltage due to lightning storms in a delta-connected system such as this would be slightly less than in systems operating with the neutral grounded, all other factors, of course, being equal, and this is also borne out by comparison with the experiences on systems of the other type, so it would seem that this data should be fairly representative of results that might be obtained in other locations under similar conditions insofar as the number of flashovers are concerned. The accompanying table gives some additional construction

SUMMARY OF FLASHOVER DATA

Section of Line	Junction - Grand Rapids		Edenville - Saginaw		Saginaw - Flint		Argenta - Battle Creek		Battle Creek - Jackson		Mio-Loud		Loud - Emery Jct.	
Frequency of current, cycles	30		60		60		30		60		60		60	
Length of line - Miles	101		40		44		26		43		32		19	
Conductor	110,000 CM. Copper		2/0 Copper		3/0 Copper		4/0 A.C.S.R.		2/0 Copper		110,000 CM. Copper		110,000 CM. Copper	
Number of years in operation	8		2		2		6		5		10		9	
Total number towers	1057		348		352		270		438		301		188	
Nominal length of span - Feet	530		660		660		530		530		530		530	
Average height lowest conductor-Feet	31		34		34		32		32		28		28	
Number discs in insulator string-Susp.	10		9		9		10		10		10		10	
-Strain	12		12		12		12		12		12		12	
Arc Protection	None		Flux Control		Flux Control		15 in.Horns		15 in.Horns		None		None	
Number Suspension Strings	2811		1020		1047		843		1345		738		509	
Number Strain Strings	744		98		210		132		173		330		110	
Total number strings, insulators	3555		1118		1257		975		1518		1068		619	
Reference Fig. 4	A		B		B		C		D		D		C	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Number suspension strings flashed over	486	17.3	34	3.3	56	5.3	73	8.7	75	5.6	43	5.8	27	5.3
Number strain strings flashed over	39	5.2	3	3.1	5	2.4	1	0.8	11	6.4	18	5.5	2	1.8
Total number strings flashed over	525	14.7	37	3.3	61	4.9	74	7.6	86	5.7	61	5.7	29	4.7
Number flashovers, top conductor	217	41	31	84	39	64	40	54	45	51	35	57	16	55
Number flashovers, middle conductor	161	31	5	13	13	21	20	27	25	29	11	18	6	21
Number flashovers, lower conductor	147	28	1	3	9	15	14	19	16	20	15	25	7	24
Number cases of damaged conductor	345	66	2	5.3	7	11.5	2	3	4	5	23	38	7	24
Number flashovers per mile of line per year	.650		.461		.691		.570		.405		.180		.170	
Failure of line due to burned wire or hardware	3		None		None		None		None		1		None	

details and a summary of the number of cases found where flashovers had occurred, their location on the tower, extent of damage to the line conductor, and other information.

Rather wide variations in the results on different sections will be noted. The Junction-Grand Rapids, Mio-Loud and Loud-Emery Junction lines of very similar construction and not equipped with arc protection show a variation from .17 to .65 flashover per mile of line per year after 8, 10 and 9 yr. operation respectively. The popular reason for this would be the variation in the severity and frequency of storms in the two localities. It is a fact that the Junction-Grand Rapids line runs north and south directly across the path of a great many storms as they pass inland off Lake Michigan, but on the other hand the Mio-Loud line follows very closely the bed of the Au Sable River, nearly east and west and lies parallel to the course of a great many storms which it is said by many have a tendency to follow the water courses.

Measurements and tests made by Peek have shown that the voltage gradient between cloud and earth in the air under a storm cloud is approximately 100 kv. per ft. under severe conditions; that the voltage induced in the transmission line will vary with the height of the line above the ground and will amount to 30 to 50 kv. per ft., depending upon the closeness of the storm to the line and other factors. Also that placing a ground wire above the line reduces the lightning disturbances from 30 to 50 per cent. The induced voltage, where the wires are placed in a vertical plane, should therefore be lowest in the conductor nearest the ground and correspondingly high in the other conductors.

The data showing the number and per cent of flashovers occurring on the top, middle and lower conductors in the table checks quite closely with this law. There are some slight discrepancies, as on the Mio-Loud and Loud-Emery Junction line, and in some cases flashovers occur on the middle and lower conductors and not on the top wire, but in general, agreement is noted. There is, however, quite a wide variation in the results in this respect between the individual lines. On the Edenville-Saginaw and Saginaw-Flint lines, equipped with flux controls, the percentage of flashovers on the middle and lower conductors are lower than on other sections of the line. This would tend to indicate that the flux control has raised the flashover voltage of the string to some extent, but not sufficiently to keep the lower conductor entirely free of flashovers. On the Edenville-Saginaw line there was but one case of flashover on the lower conductor over the two-year period. The sphere gap effect of the tubular horn used with the flux control may perhaps have some effect, together with the shielding effect of the control insulator.

A comparison of the Edenville-Saginaw line with the Junction-Grand Rapids line shows a wide variation in this respect. The Junction-Grand Rapids line shows the smallest percentage of flashovers on the top phase, while the Edenville-Saginaw line shows the greatest with a wide variation over the three wires in spite of the higher nominal elevation of the conductors. In looking for other reasonable explanations for this difference, the possibility of soil conditions being somewhat responsible is suggested. The curves in Figs. 4 and 5 show a comparison of ground resistance measurements

with the number of flashovers on the Junction-Grand Rapids and the Battle Creek-Jackson lines. That there is some relation between ground resistance and the number of flashovers seems apparent by the fact that both increase and decrease correspondingly with one or two exceptions which might be accounted for by abnormal local conditions.

Peek has called attention to the "water level" below the surface of the ground, as being the effective ground

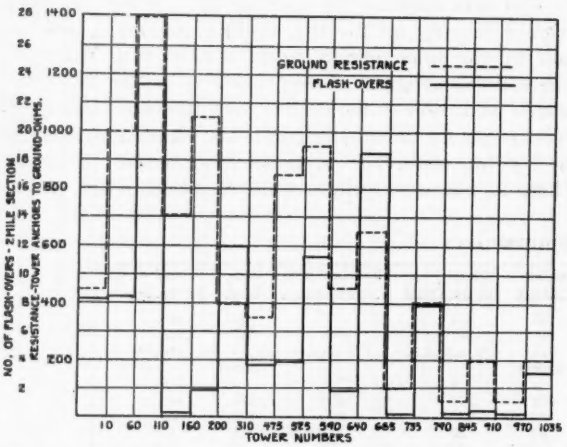


FIG. 4. NUMBER FLASHOVERS COMPARED TO GROUND RESISTANCE ON THE JUNCTION-GRAND RAPIDS LINE

level, and that under equal conditions an induced voltage is higher in dry sections because of the fact that the flux extends from cloud to water level, and the effect is that of increasing the height of the line.

Referring to Fig. 4, it is noted that the ground resistance along the Junction-Grand Rapids line is very high, reaching a maximum of 1160 ohms. The soil along this line is very dry and sandy and in some small sections is almost devoid of vegetation. The country along

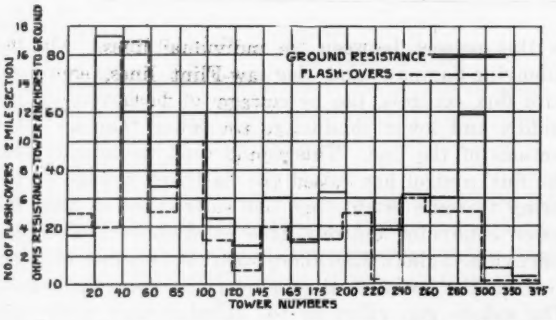


FIG. 5. NUMBER FLASHOVERS COMPARED TO GROUND RESISTANCE ON BATTLE CREEK-JACKSON LINE

this line is slightly more rolling in places than along some of the other lines, but not enough apparently to affect conditions to any extent. The high resistance measurements were not confined to the higher points but were found in all locations. The soil on the Edenville-Saginaw line represents perhaps the other extreme, being low and marshy with a considerable amount of heavy clay soil, and the water throughout this district is of a salty nature. A sufficient number of ground resistance measurements along the Edenville-Saginaw line were not available to plot a curve, but those taken indicate a resistance of not over 4 ohms.

Conditions along the Battle Creek-Jackson line show lower ground resistance than the Junction-Grand Rapids line, varying between 10 and 100 ohms. The conductors being lower probably helped, but was offset to some extent by the small arcing horns which probably increased the number of flashovers. The per cent of flashovers on the top conductor on this line is smaller than any other except Junction-Grand Rapids, and the other lines follow this trend, varying in proportion to the ground resistance.

With the increased effective height of the lines with higher ground resistance, all three of the conductors are well within the flashover voltage range and the effect of the difference in the height of each of the three conductors is proportionately smaller. On the Edenville-

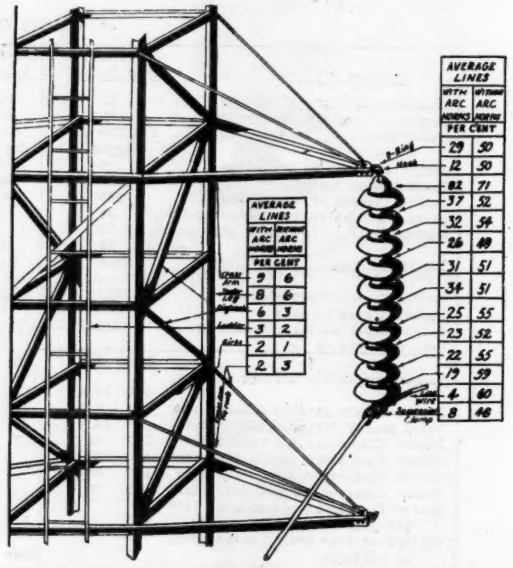


FIG. 6. RELATIVE LOCATION OF BURNS CAUSED BY FLASHOVERS

Saginaw line apparently the closer proximity of the lower wire to the effective ground level makes it almost immune to flashovers in spite of the higher nominal span. It also lowers the number of flashovers on the middle wire, but the height of the top wire raises it to within the range of the flashover voltage. The shorter strings of insulators on this line undoubtedly had some detrimental effect. Results of this kind suggest that the lines should be so constructed that all three conductors will be a minimum distance from ground or in a horizontal plane.

It has been supposed that flashovers might increase with the mileage of line, but the results on the Jackson-Battle Creek line, which is separated from the remainder of the system, does not bear out this theory and inasmuch as the lightning surges travel but a short distance, it is reasonable that there would be no great difference.

Comparing the lines equipped with the flux controls and arcing horns with the others, the rather remarkable efficiency of the arc protection in reducing the damage to the conductor is noted. A decrease from 66, 38 and 24 per cent on the lines not equipped to 3 and 5 per

cent on those equipped with arcing horns and 5.3 and 11.5 per cent on those with flux controls is shown, the arcing horns being somewhat more effective than the flux controls. It will also be noted that there have been no failures due to burning of the conductor or insulator hardware on any line equipped with either type of horn which also emphasizes the advisability of providing some form of arc protection.

The conditions that were found on the Junction-Grand Rapids line with its 66 per cent of burns offer an excellent example of what may be expected of a line constructed in a locality of this kind without arc protection to the conductor or some means of holding down the lightning potentials.

It will be noted that the number of failures of the line due to the arc burning off the conductor, or some part of the insulator string at the time of the flashover, is rather small. There have been a total of only three in the eight years of operation on the Junction-Grand Rapids line and one on the Mio-Loud line. This, of course, is an excellent service record; however, of the 345 cases of damage found on the Junction-Grand Rapids line, a great many were so serious as to necessi-

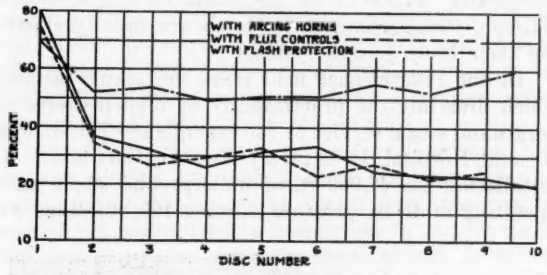


FIG. 7. CASCADING OF INSULATORS WITH AND WITHOUT ARC PROTECTION

tate immediate repairs. Where the damage is not so great, there is, of course, some weakening of the conductor. This creates the hazard of failure at some future time when abnormal mechanical stresses are imposed upon the conductor, such as during severe sleet storms, and some failures of conductors on this line during sleet storms that have occurred in the past are now suspected of having been at least partly due to this weakened condition of the wire. Aside from the damage to the conductor, the arcs do not seriously damage the other equipment.

The arcs shift around considerably over the surfaces upon which they are playing. The theory has been advanced that the arc causes a separate burn with each half cycle. The appearance of the spots tends to bear this out. The small round burns are found to be deeper and more severe on the 30-cycle than on the 60-cycle system due apparently to the greater duration in each location at the lower frequency. Using the number of spots found as an indication of the length of time the flashover exists, it is thought that a great many of the flashovers are of very short duration, considerably less than one second; others, however, hold longer and evidently are the ones that cause the more serious damage.

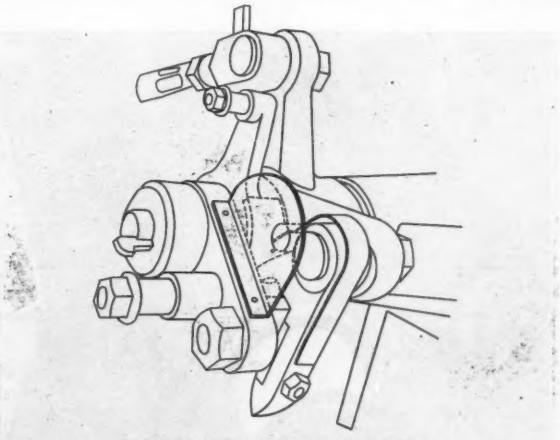
In Figure 6, an effort has been made to show the conditions found relative to the travel of the arc and the cascading of the insulator strings. A typical tower top with the location of the burns that were found on lines with and without arc protection is shown. The figures opposite the insulator string and tower show the per cent of burns found on the different pieces of equipment with reference to the total number of flashovers.

Figure 6 shows again the marked decrease in the amount of damage to the line conductor and clamp where arcing horns are used. This data is also of interest in showing that an extremely high percentage of the flashovers occur over the insulator string and do not take place between the conductor and tower independent of the insulator string as has been thought. The cascading and burning of the caps, except at the end of the strings, apparently takes place at the time of the initial flashover as tests that have been made on various types of arcing horns show that there is a strong tendency for the power arc to blow away from the string in nearly all cases, regardless of the type of arc protection in use. During part of the 1926 lightning season, there was a new line between Argenta and Battle Creek on the opposite side of the tower from the old one which had not been put in service and had both ends grounded. An inspection showed that several flashovers had occurred on this dead line and the caps show burns similar to those on the live lines.

The curves in Fig. 7 also show the amount of cascading quite clearly on the lines with and without arc protection. The curves show the effectiveness of these particular types of arc protection in reducing the amount of cascading.

Safety Guard for Corliss Valve Gear

ACCIDENTS with Corliss valve gears are perhaps not as common as formerly, but this argument should not be used as an excuse for neglecting proper safety meas-



IRON PLATE COVERS VALVE GEAR

ures. A badly crushed hand and loss of two fingers when a new oiler got caught between the hook and steam arm led an enterprising engineer to put the safety guard, shown in the illustration, on all his engines. This guard can be made from 10 gage black or galvanized iron in a few minutes and precludes any possibility of accident at this point. At the same time it does not interfere in any way with the operation or accessibility of the valve gear.

Underground Steam Distribution Systems

HIGH PRESSURE STEAM FROM CENTRAL BOILER PLANT SERVES MANY PURPOSES BESIDES AFFORDING CLEANLINESS, HEALTH AND CONVENIENCE IN CITIES. BY L. A. FOSTER

COMPLETE figures on the growth of all kinds of business during recent years, as measured by capital required, show that public utility companies lead the whole list. Offhand, we visualize such investments in the form of enormous hydroelectric plants, massive steam generating stations and hundreds of miles of interconnected electric distribution systems. Their very bulk and immensity lend readily to the popular mind that they represent heavy investment in capital. So accustomed are we, of the large cities, to these agencies which are visible above the ground, and how vital they are to daily existence, it might be interesting to take note of what lies beneath our feet. We are all conscious of our cities' water and sewer systems, but unless one is particularly interested, it is easy to overlook the rapid development of the present day high pressure steam distribution systems which serve practically every business district of our largest cities.

This rapidly developing medium of public service is of vital importance to the welfare of our major cities. Consequently a fair share of the capital which is now being invested in public utilities, is being used to construct such systems, whose usefulness is not merely confined to the heating field.

In addition, for example, steam is supplied from large central stations in this manner for the requirements of laundries, hotels, manufacturing and industrial plants. To the user such service affords: cleanliness, comfort, health, convenience, safety and lower building investment, while to the community served there is elimination of smoke, economy in fuel consumption, traffic relief and reduced fire hazard.

Congested districts, of course, offer a particular field for such distribution systems. New York City has by far the largest steam system serving commercial buildings and apartments. Power plants with a combined capacity of approximately 75,000 b.hp. are devoted to the generation of high pressure steam for such service. Many of the large buildings served operate their power and electric plants by drawing on the underground system to drive their engines. Approximately 2000 customers are served from a total of approximately 200,000 ft. of underground mains. This system represents an investment of approximately $18,000,000.

In Detroit there is also an enormous high pressure distribution system served by approximately 30,000 b.hp., distributing to approximately two thousand customers, with a total demand of 4,000,000 ft. of steam radiation connected to the system. In a recent year the pounds of steam sold amounted to 1,730,000,000.

San Francisco ranks well up with a system of approximately 44,500 ft. in use, while Cleveland, Boston, Chicago, Pittsburgh and St. Louis are rapidly expanding their underground systems.

In the institutional field there are many instances which illustrate the practicability of high pressure underground steam service as for example the Fitzsimmons General Hospital, U. S. Army, Denver, Colorado. This installation has 42,000 ft. of underground steam mains operating at 45 lb. pressure, serving 105 buildings with

FIG. 1. UNDERGROUND PIPE LINE FOR 175-LB. STEAM PRESSURE SHOWING INSULATION, WATER PROOFING, BUTT WELDED JOINT AND HALF SECTION OF PIPE GUIDE

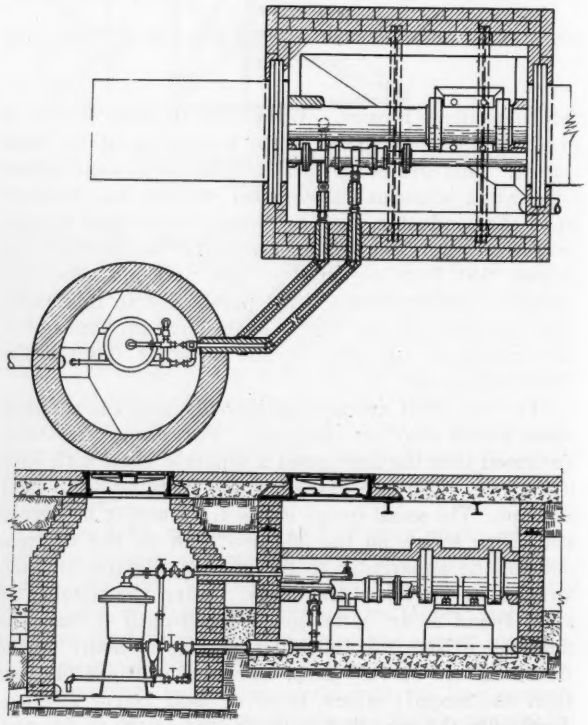


FIG. 2. TYPICAL 10-IN. STEAM MAIN ANCHOR MANHOLE WITH STEAM TRAP CONNECTIONS AND SEPARATE STEAM TRAP MANHOLE

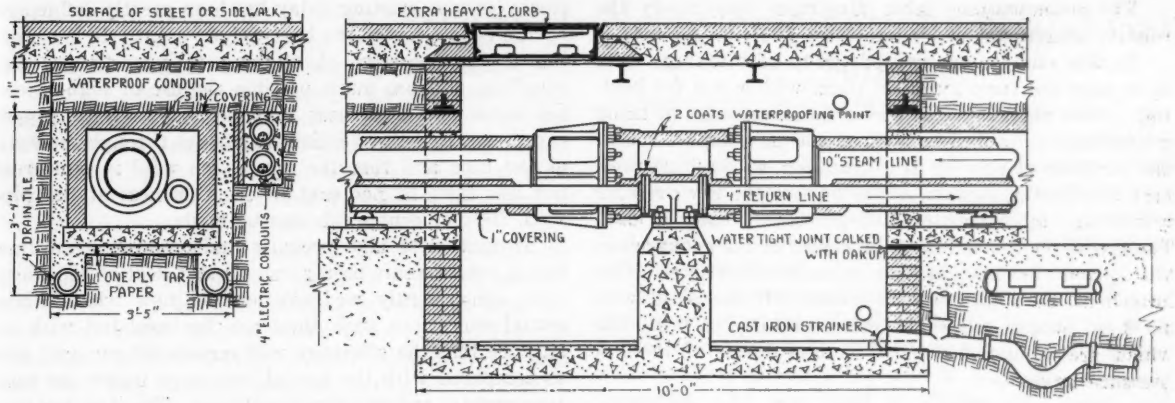


FIG. 3. ELEVATION AND CROSS SECTION OF TYPICAL UNDERGROUND STEAM PIPE LINE AT EXPANSION JOINT

a connected load of 230,000 sq. ft. of radiation. Another notable example is Manhattan State Hospital, Wards Island, New York City, which consists of a group of 98 buildings, steam service being supplied from both underground and overhead high pressure steam lines.

In the university field, Cornell is a fine example of the use of the underground medium of steam distribution to a large group of buildings, as a few years ago the old low pressure heating equipment was replaced with approximately 20,000 ft. of high pressure underground lines, steam being fed from a modern power plant of a designed capacity of 5500 b.hp.

Industrially the application of underground high pressure systems has been fully appreciated for some years. Many public utility plants over the country have high pressure feeders leading out to various manufacturing plants, in which the steam is used in various processing applications. The oil industries have for some years used this medium for the transportation of steam in large refineries over relatively long distances, while steel and other major industries are utilizing the advantages this arrangement offers.

With particular reference to high pressure underground lines in the public utility field, they are an outgrowth of the old low pressure exhaust heating systems. The load on these systems had increased heavily to keep pace with the modern trend of congested down town district and to compete in cost with heat and power service of individual plants it was necessary to take advantage of the economies offered by larger and more modern plants. Rather than rebuild the existent low pressure systems it was economy to feed them with high velocity feeders over comparatively long distances, the source of supply being the new modern plants. The high velocity and pressure as used today, as mentioned above, have made it possible to reduce the cost of installation of such lines as compared to relative cost of a low pressure line which would deliver the same amount of steam per hour over the same distance—velocities ranging from 15,000 to 30,000 ft. per min. are not uncommon.

COMPARISON OF INVESTMENTS IN HIGH AND LOW PRESSURE STEAM PIPING SYSTEMS

Location		165 LB. HIGH PRESSURE MAIN						10 LB. LOW PRESSURE MAIN					
		Dimensions			Total Cost			Dimensions			Total Cost		
From	To	Supply Diam. in in.	Return, Diam. in in.	Length, ft.	Present Loads	Immediate Future Loads	Ultimate Future Loads	Supply, Diam. in In.	Return, Diam. in in.	Length, ft.	Present Loads	Immediate Future Loads	Ultimate Future Loads
ROUTE "A":													
Municipal Service Building	City Hall	8	3	671	$20,296			20	3	671	$44,187		
City Hall	Auditorium	6	3	805		$11,879		16	3	700		$27,275	
Auditorium	Memorial Building	3	2-1/2	630		5,314		4	2-1/2	630		5,024	
Memorial Building (Tie line)	Hall of Records	3	2-1/2	440			$ 3,955	4	2-1/2	440			$ 4,219
ROUTE "B":													
Municipal Service Building	New Court House	6	3	1020		19,160		18	3	1020		50,222	
New Court House	Federal Building	5	3	770			10,131	14	3	770			21,242
Federal Building	Board of Education	5	3	500			5,385	12	3	500			8,994
Board of Education	Museum	4	2-1/2	250			3,051	10	2-1/2	250			5,362
Museum	Hall of Records	4	2-1/2	240			2,498	10	2-1/2	240			4,243
Board of Education	Library	4	2-1/2	400			4,196	10	2-1/2	400			7,125
Totals					$20,296	$36,353	$29,216				$44,187	$82,521	$51,175

	Low Pressure	High Pressure	Excess of Low Pressure over High Pressure	
Present load	$44,187	$20,296	$23,891	$23,891 = Total excess of low pressure over high pressure cost for immediate future loads, or 117 per cent
Immediate future load	82,521	36,353	46,168	70,059 = Total excess of low pressure over high pressure cost for immediate future loads, or 123 per cent
Ultimate future load	51,175	29,216	21,959	
Totals	$177,883	$85,865	$92,018	92,018 = Total excess of low pressure over high pressure cost for ultimate load, or 107 per cent.

The accompanying table illustrates very nicely the relative investment of low and high pressure systems.

In this study a centralized group of buildings were to be supplied from a central plant with steam for heating. After carefully comparing the advantages of using generating units and exhaust steam as compared with the purchase of current in conjunction with a high pressure distribution system, it will be seen the low pressure system ran approximately 100 per cent greater in cost. The steam plant was located in center of the group while the system led out in two opposite directions. One branch of the high pressure system left the plant with an 8-in. supply while the other required a 6-in. line which are comparable to 20-in. and 18-in. of the low pressure system.

Adaptation of Superheat

Adaptation of superheat in the transmission of steam in underground high pressure steam lines has been accomplished with complete success. Its use, of course, has materially affected the manner and cost of installation but even the slightly increased cost of such lines has been justified where the character of the service called for perfectly dry steam for use in generating units and other process work. Superheat further has materially reduced line losses, as the heat loss can be confined strictly to the loss of superheat, such losses being considerably less than that suffered in the case of saturated steam. The following test data illustrates this point clearly:

FIG. 4. TWO SINGLE STEEL EXPANSION JOINTS WELDED BACK TO BACK IN LINE CARRYING 175 LB. STEAM PRESSURE

Data	Saturated steam flowing	Superheated steam flowing
Pounds of condensation per hour in 1250 ft. of 10-in. line	303.5 lb.	None
B.t.u. lost per hour per sq. ft. per degree difference or value of K	.219	.113

Note that with the use of superheated steam the value of K is reduced approximately 51 per cent in this installation.

Rapid development of high pressure underground steam lines as existing today has been greatly influenced by the reliability of the butt welded joint. It has eliminated the necessity of burying fittings, flanges and coupling, and has made possible the use of higher temperatures and superheat with security. With proper care to see that the welding penetrates through the walls of the pipe and that the top of the weld is reinforced not less than 10 per cent of the thickness of the pipe wall, 100 per cent welds can be made.

Insulation of high pressure underground steam lines has in recent years been given a great deal of consideration, consequently we have arrived now where under actual conditions such lines can be insulated with assurance that the efficiency will remain 90 per cent plus as compared with the loss of bare pipe under the same temperature and pressure conditions. This fact has been materially aided by proper attention to the under drainage of the entire conduit and close attention being paid to the water proofing of the conduit joints and insulation surfaces. The proof of these statements probably is better shown by the actual result of some line loss test. The following data illustrates such a test on saturated lines:

Saturated Steam Flowing in 3600-Ft. U. G. Line

Sq. ft. of pipe surface area	11,664
Line loss in lb. of steam per hour	1,232
Steam temperature, deg. F.	380
Ground temperature, deg. F.	50
Temperature difference, deg. F.	328

$1232 \div 11{,}664 = 0.106$ lb. of steam loss per sq. ft. per hr. of pipe surface.

0.106×847 (latent heat) $\div 328 = 0.27$ loss in B.t.u.

Bare pipe loss under same temperature difference = 3.29 in B.t.u.

$$\text{Efficiency} = \frac{3.29 - .27}{3.29} = 91.7 \text{ per cent.}$$

The high pressure system installed at Cornell University further illustrates the remarkable high efficiency which can be obtained. The specification called for efficiency of not less than 90 per cent. To determine this a test was conducted on 5047 ft. of underground main consisting of 5, 6, 8 and 10-in. lines under a pressure of 153½ lb. The result proved an efficiency of 92.77 per cent, or it exceeded the guarantee in that the heat loss was only 7.23 per cent of bare pipe loss where the specification allowed a loss of 10 per cent.

Auxiliary Equipment

With the advent of underground high pressure mains, considerable thought has been given to arrangement of pressure reduction stations to step down the line pressures to supply various forms of service demanded. For extreme reductions it has been found logical to make it in two steps, say from 150 lb. to 80 lb. or 70 lb. and then down to low pressures. Bypasses have provided the means to allow repairs without interruption of service. Relief valves are ordinarily being installed on the low side of the reducing valve for protection, while flow meters have been adapted skillfully to the scheme for accurate measurements of steam usage. Various forms of steam strainers have been added to afford protection to the functioning of the reducing valves, meters, and traps. Expansion joints to care for pipe movement

have advanced wonderfully in design and today they are obtainable in standard sizes up to 48 in. and for use with 250 lb. pressure, and for 300 deg. F. superheat.

Another important auxiliary is the alinement guide developed specifically for underground high pressure steam lines to assure correct alinement of the mains, thus alleviating the expansion joints of undue strains. Steam traps also have received their share of attention for adaptation to underground conditions. The isolating of them in separate manholes apart from the main lines has aided greatly the ease and safety of maintenance work. In some cities some trouble has been encountered in gas accumulations in manholes, but the installation of vent or relief pipes leading above ground has been a step forward in counteracting this menace.

Economics

Economics, of course, have played a major part in the development of the underground high pressure systems, while science and sound engineering have followed closely to make such a development practical and successful. Of course, many ventures have not been financially successful but courage and persistence have overcome this.

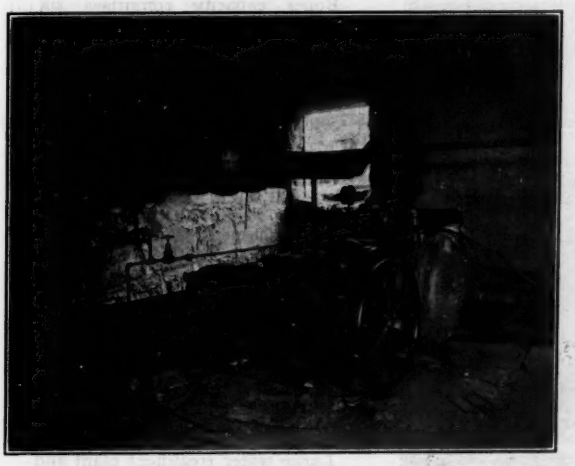


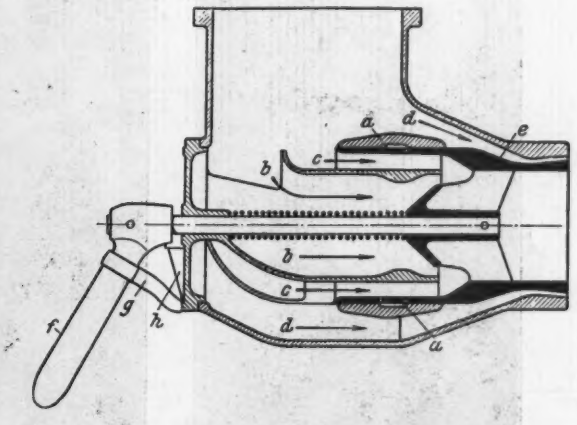
FIG. 5. PRESSURE REDUCING SUBSTATION SHOWING REDUCING VALVE BETWEEN HIGH AND LOW PRESSURE GATE VALVES, ALSO REDUCING VALVE IN BYPASS LINE

With higher standards of service and reliability established in most cities, attention has been focused upon the revenue possible with careful management and just rates, and the result is that such projects are emerging on a basis where future success is assured. Sufficient density of heating load per unit of line as compared to the investment and operation will continue to be the controlling factor of financial success. While this is true in the congested districts, it is not so in the industrial field. If the load demand is large enough the delivery of steam can be profitably made over comparatively widely separated points of production and consumption. Reliability of service is probably the most important factor to be considered in this regard. Late development to safeguard this included either an emergency plant at the end of a lengthy line, or the line is paralleled with a duplicate line to meet an interruption of service.

New Combination Oil and Gas Burner

COMPLETE COMBUSTION of the fuel and easy simultaneous regulation of the oil or gas and air supply for all loads at all times with a minimum volume of excess air, high combustion temperature, wide range of fuels from gases to heavy tars, and effective operation by unskilled labor are some of the objectives of an efficient combination oil and gas burner.

Recently a new development of the Hetsch oil burner was described in the VDI Zeitschrift. The burner is reported to burn equally well gases, oils of high viscosity and tars containing pitch and a high percentage of insolubles. In one plant a 3929-sq. ft. water tube boiler with an 1100-sq. ft. superheater is provided with eight burners with a capacity of 1650 to 10,595 cu. ft. of gas per hr. During a 6-hr. test, 1407 lb. of oil with a heating value of 13,298 B.t.u. per lb. was burned. This corresponds to 175 lb. per hr. per burner. The average CO_2 content was 14.9 per cent, the temperature of the exit gas 419 deg. F. A total of 91,808 lb. of feed water was evaporated into steam at 235 lb., 195 deg. superheat giving a boiler efficiency of 88.6 per cent. An efficiency of 90 per cent is reported in the marine boiler.

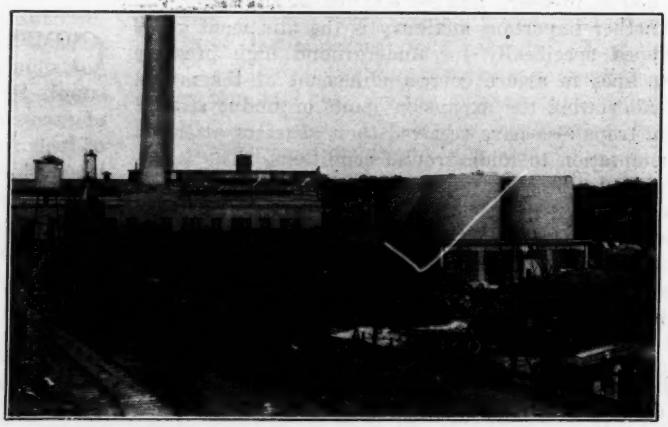


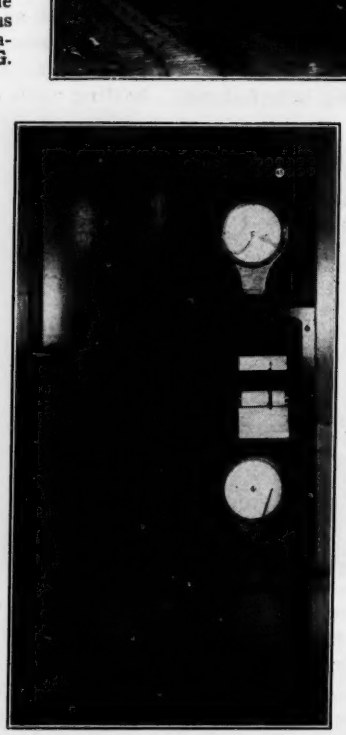
CROSS SECTIONAL VIEW OF THE HETSCH OIL BURNER. A. OIL CHAMBER, B., C. AND D. AIR PASSAGES, E. CONTROL PISTON

As seen in the illustration, the Hetsch oil burner has spiral shape coils inside the mixing nozzles. These coils cause the middle and the main streams of air to whirl thoroughly with the primary air and oil mixture. The same construction is used in the combination oil and gas burner. Gas is fed into the burner through the air passage where it is caught by the whirl in the air mantle and thoroughly diffused in the air, the mixture now rotating leaves the burners and is carried around by another air mantle which also flows under the steam pressure from the burner. The flame is not pointed and has a length of from 18 in. to several feet, according to the size and adjustment of the burner. One can change from oil to gas or back again by turning several valves. The municipal gas plant at Mannheim has for a number of months fired a Cornish boiler with this combination burner using alternately sulphur gas, tar and occasionally illuminating gas.

Features of Interest at Mahoningside Station

AT WARREN, OHIO is located the Mahoningside Station of the Ohio Public Service Co., the illustrations showing two of the interesting features of the plant, which has generating capacity of about 45,000 kw. Directly below is shown the load indicating system. At the left, just above the master pressure gage in the boiler room, is the illuminated load indicating dial, actuated from a graphic kilowatt meter. At the right is shown the load panel in the superintendent's office, about 200 ft. away. At the top of this is the load indicator in parallel with the one in the boiler room. Below it are a recording steam pressure gage, a frequency recorder and a recording voltmeter. The superintendent, C. H. Byers, can thus determine the exact conditions of operation without leaving his office. D. G. Waggoner is production engineer.





Boiler capacity comprises six 1013-hp. stoker fired boilers, six 512-hp. stoker fired boilers and five 512-hp. pulverized coal fired boilers. Below are shown the unit pulverizers recently installed with the five 512-hp. boilers, replacing stokers, the furnaces having been remodeled. Coal is run-of-mine and slack, averaging about 5 per cent moisture and 13,000 B.t.u. per pound. It is pulverized so that about 60 per cent passes a 200-mesh screen. At boiler ratings as high as 275 per cent, the combustion rates have been 28,450 B.t.u. per cubic foot. Average boiler efficiencies of about 75 per cent have been maintained with these units. Power consumption of the pulverizers is about 14 kw-hr. per ton and furnace maintenance is low. Both fantail burners and turbulent burners are employed.

Large water treatment plant and simple, rugged coal handling system are other features of this station, which has shown good economy and is typical of the attention given to operation in the moderate-sized central stations often found in our large public utility systems.

Cold Storage Operation and Computations

EFFECT OF VARIOUS FACTORS UPON THE REFRIGERATING REQUIREMENTS SHOWN BY CALCULATION. BY W. R. WOOLRICH*

COLD STORAGE HOUSES to be effective must be properly constructed and properly located. To be a financial success they should be built where railroad facilities are ample and at a point from which wholesale distribution is readily promoted. Often this may be at a point on the main railroad en route from the point of production to that of consumption, but the more natural point of storage is near either the point of production or consumption since this saves a double freight handling charge on the goods.

A walk through some of our American storage houses reveals many things to be avoided in storage house construction; low beams, inconvenient air ducts and dripping ceilings all indicate that the net income possibilities have been considerably reduced by lack of forethought in design.

Fireproof construction is recommended for all cold storage work. In making a building fireproof, it is readily made also rodent and decay proof, and fireproof materials lend themselves readily to a construction that eliminates overhead beam obstructions. Cantilever slab

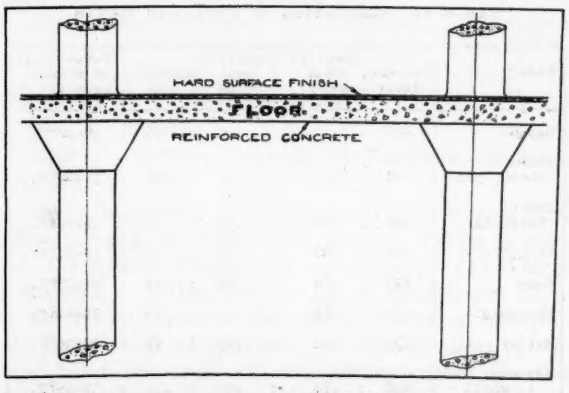


FIG. 1. CANTILEVER SLAB FLOOR CONSTRUCTION FOR COLD STORAGE BUILDINGS

reinforced concrete construction, shown diagrammatically in Fig. 1, is usually best adapted to storage house operation. This permits running overhead refrigeration pipes in any direction since there is no beam or girder obstruction. Likewise an air duct, or any similar overhead framework, can be installed without obstruction. The absence of beams and girders improves the light distribution and permits the loading of trucks to nearly the full height of the room.

REFRIGERATION REQUIRED

For estimating, it is the practice of many refrigeration engineers to allow one ton of refrigeration for each 4000 ft. of freezer space and one ton for each 8000 ft. of cold storage space. These values are good for certain conditions but may be in error easily 100 per cent, thus should not be used without question.

The factors that must be considered in cooling a room are:

1. Number of changes of air in the room in 24 hr.
2. Insulation of room.
3. Size of room.
4. Differences of temperature between inside and outside.
5. Quantity and character of material in storage.

EFFECT OF CHANGES OF AIR UPON REFRIGERATION REQUIREMENTS

Changes of air are brought about in many storage buildings by leakage through doors, elevators and windows and by infiltration through the walls. In other houses fresh air is introduced to reduce the percentage of CO_2, the undesirable odors and the foul gases.

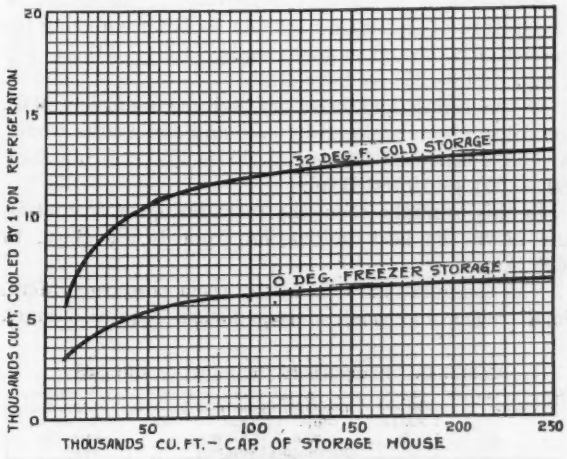


FIG. 2. CURVES SHOWING RELATION BETWEEN REFRIGERATION REQUIRED AND SIZE OF STORAGE HOUSE

To show the air change effect on the refrigeration requirements of a cooling room 50 by 20 by 10 by 10,000 cu. ft., the refrigeration required will be computed for one air change per 4-hr. period with outside temperatures averaging 80 deg. F. and the room at 35 deg. F.

One ton of refrigeration equals 288,000 B.t.u. per 24-hr. period or 200 B.t.u. per min. The weight of a cubic foot of air at 35 deg. F. is .08 lb.

The specific heat of air at this temperature is .24.

The heat that will have to be extracted every 24 hr. will be: $0.08 \times 50 \times 20 \times 10 \times 0.24 \times (80 - 35) \times \frac{24}{4} = 63{,}360$ B.t.u.

This is equal to .22 tons of refrigeration just to cool to 35 deg. F. the six changes of air in 24 hr.

EFFECT OF INSULATION

The function of the insulation is to cut down the heat transfer by conduction through the several sides of the room. In cold storage, it is only necessary to consider those sides of the rooms where there is a difference of temperature within and without the room walls. In this problem it will be assumed that the floor, ceiling,

*Professor of Mechanical Engineering, University of Tennessee.

TABLE I. WEIGHT OF DRY AIR PER CU. FT. AT DIFFERENT TEMPERATURES (STANDARD BAROMETER)

Temperature Degrees F.	Weight in pounds per Cubic Foot
30	.081
35	.080
40	.079
45	.078
50	.077
60	.076

one side and one end are surrounded by rooms of similar temperature.

This would leave heat transfer through the walls on one end and one side between the atmosphere at 80 deg. F. and the room at 35 deg. F. We will assume the storage house has a 14-in. brick wall with a 3-in. cork board lining. From insulation tables this will conduct .07 B.t.u. per sq. ft. of wall surface per hr. per deg. of temperature difference.

Wall area $\times$ factor of conductivity $\times$ difference in temperature of inside and outside = B.t.u. entering by conductivity through outside walls. $[(50 + 20) \times 10] \times 0.07\ (80 - 35) = 2695$ B.t.u.

If the lining had been omitted the coefficient 0.07 would have been replaced by 0.28 and the results would have been increased 4 times. $[(50 + 20) \times 10] \times 0.28\ (80 - 35) = 10{,}780$ B.t.u.

In this example, then, the room lining or insulation cuts down the heat infiltration from 10,780 B.t.u. to 2695 B.t.u.

The computations effected by room size are evident. Small rooms and small storage houses require a much greater amount of refrigeration per cubic unit than large rooms and houses. This is caused by:

1. Greater percentage of total change by door and window openings.
2. Greater average percentage of wall surface surrounded by high temperatures.

Effects of Outside Temperature

Since heat flow is proportional to the temperature difference inside and outside the room, the other factors remaining constant, temperature requirements and conditions greatly effect refrigeration demands.

TABLE II. PROPERTIES OF DAIRY PRODUCTS

Product	Per cent Water	Specific Heat above Freezing	Specific Heat below Freezing	Latent Heat	Temperature at which usually kept
Butter	10%	.64	.34	15	20-35°F.
Buttermilk	91%	.92	.48	131	32-40°F.
Cheese, American	35%	.64		50	32-34°F.
Cheddar					36-38°F.
Cheshire					38-40°F.
Limburger					42-44°F.
Neufchatel					50-52°F.
Roquefort					39-41°F.
Whole Milk					34-36°F.
Skim Milk					45-48°F.
Eggs	73%	.76	.40	105	33-35°F.
Ice Cream	67%	.78	.45	96	5-15°F.
Milk	87%	.90	.47	127	32-36°F.
Oleomargarine	9%	.65	.35	14	25-30°F.

TABLE III. PROPERTIES OF FRUITS

Fruits	Average Percent Water in Fruits	Temperature at which Fruits are Usually kept	Fruits	Average Percent Water in Fruits	Temperature at which Fruits are Usually Kept
Apples	84%	32-34°F.	Dates	18%	50-55°F.
Apricots	85%	35-40°F.	Grapefruit	88%	33-36°F.
Bananas	75%	35-40°F.	Lemons	89%	38-40°F.
Blackberries	89%	36-40°F.	Grapes	75%	30-35°F.
Cantaloupes	89%	35-40°F.	Oranges	87%	40-50°F.
Cherries	84%	38-40°F.	Peaches	87%	35-40°F.
Cranberries	88%	33-36°F.	Pears	63%	32-36°F.
Currants: Dried	28%	40-45°F.	Pineapples	65%	32-40°F.
Strawberries	90%	33-40°F.	Plums	75%	32-36°F.

TABLE IV. PROPERTIES OF VEGETABLES

Vegetable	Average Percent Water in Vegetable	Temperature at which Veg. are Usually kept	Vegetable	Average Percent Water in Vegetable	Temperature at which Veg. are Usually kept
Asparagus	94%	33-34°F.	Lettuce	94%	30-42°F.
Beans, G green	88%	33-34°F.	Onions	88%	32-35°F.
Beets	90%	32-40°F.	Parsnips	83%	33-35°F.
Cabbage	91%	31-36°F.	Peas	75%	32-36°F.
Carrots	86%	33-36°F.	Potatoes Irish	79%	36-40°F.
Cauliflower	91%	30-32°F.	Potatoes, Sweet	71%	50-55°F.
Celery	94%	32-34°F.	Radish	91%	32-35°F.
Corn, green	75%	36-38°F.	Squash	86%	33-36°F.
Cucumbers	96%	36-40°F.	Tomatoes	95%	35-40°F.

TABLE V. PROPERTIES OF FISH AND MEATS

Name	Percent Water	Specific Heat above Freezing	Specific Heat below Freezing	Latent Heat	Temperature at which usually kept
Bacon	20%	.50	.30	28	30-32°F.
Beef-Fresh, lean	72%	.77	.41	102	36-40°F.
Beef-Fresh, fat	54%	.60	.34	76	36-40°F.
Fish, fresh	76%	.82	.43	110	15-20°F.
Game	80%	.80	.42	115	20-25°F.
Mincemeat	56%	.60	.34	79	36-40°F.
Mutton	67%	.81	.67	95	32-36°F.
Oysters, in shell	80%	.84	.44	115	30-35°F.
Oysters, in liquid	88%	.90	.47	127	30-35°F.
Pork, fresh	46%	.51	.30	65	32-36°F.
Pork, salt	12%	.46	#	15	32-38°F.
Poultry	60%	.80	.42	85	28-30°F.
Pigeons	70%	.78	.41	99	28-30°F.
Veal	63%	.70	.39	89	34-40°F.

Will not freeze, on account of salt content, at normal freezing temperature.

Freezer storage in Birmingham with an average yearly atmosphere temperature of 63 deg. F. is a much different problem than freezer storage in Milwaukee with an average yearly temperature of 45 deg. Freezer storage at 15 deg. F. produces a far less refrigeration demand than freezer storage at 0 deg. F. Equally, cold storage is effected by similar factors, and the smaller the storage the more greatly is this effect felt.

With the average cold storage plant, the operating force soon learns the requirements and characteristics of each storage room. The first four factors just dis-

cussed become fairly well stabilized from week to week and no great cold storage demand changes are made from these sources.

The nature and quantity of incoming and outgoing perishables are usually the questionable problem with the operating force. This is especially true in the freezer rooms if the storage periods are short. In computing the heat removal necessary in the refrigeration, several examples will be considered.

Case 1. Cooling Materials to Temperature above Freezing.

When materials are placed in cold storage to be cooled to a temperature above that of freezing, the values that must be known to compute the amount of heat to be removed are: (a) Weight of material. (b) Required change in temperature. (c) The specific heats of the material above freezing.

For example, if 10,000 lb. of onions are received at 75 deg. F. to be cooled to 32 deg. F., the following computations would give the heat removal required from the onions:

From Table IV the specific heat of onions above freezing is 0.9.

The temperature drop is 75 — 32, or 43 deg. F.

The heat to be removed will be then

$$10{,}000 \times 0.9 \times 43, \text{ or } 387{,}000 \text{ heat units.}$$

This corresponds to $\frac{387{,}000}{144}$ or 2687.5 lb. of refrigeration, or $\frac{387{,}000}{288{,}000} = 1.3$ t.

Case 2. Cooling Materials to Temperatures below Freezing.

When materials are to be cooled to a temperature below freezing, the values that must be known to compute the amount of heat to be removed are: (a) Weight of material. (b) Required change in temperature above 32 deg. F. (c) Specified heat above freezing of material. (d) Latent heat of material. (e) Specific heat of material below freezing. (f) Temperature below freezing to which material is to be cooled.

For example, if 20,000 lb. of fish are received at 72 deg. F. and are to be frozen and stored at 24 deg. F., the following computations would be necessary:

From Table V the specific heat of fish above freezing is .82.

The temperature change above freezing is 72 — 32, or 40 deg. F.

The heat to be removed above 32 deg. F. is then,

$$20{,}000 \times 0.82 \times 40, \text{ or } 656{,}000 \text{ B.t.u.}$$

But at freezing, fish have a latent heat of fusion of 110 B.t.u. per lb. To freeze, then, will require $110 \times 20{,}000$, or 2,200,000 B.t.u.

Below freezing, these same fish have a specific heat of 0.43.

The temperature change below freezing is 32 — 24, or 8 deg. F.

The heat to be removed below 32 deg. F. will be then, $20{,}000 \times 0.43 \times 8$, or 68,800 B.t.u.

The total heat removed in cooling the 20,000 lb. of fish is as follows:

Heat removed from 72 deg. F. to 32 deg. F.	656,000 B.t.u.
Latent heat removed at 32 deg. F.	2,200,000 B.t.u.
Heat removed from 32 deg. F. to 20 deg. F.	68,800 B.t.u.
Total heat removed	2,924,800 B.t.u.

This corresponds to $\frac{2{,}924{,}800}{144}$, or 20,300.12 lb. of refrigeration, or $\frac{2{,}924{,}800}{288{,}000} = 10.15$ t. refrigeration.

Latent Heat Values

Occasionally, by communication or otherwise, requests come for data on the latent heat of certain commodities that must be frozen. For all practical purposes the latent heat can be computed by multiplying the percentage of water in the commodity by 143.4, the latent heat of fusion of the water in the commodity.

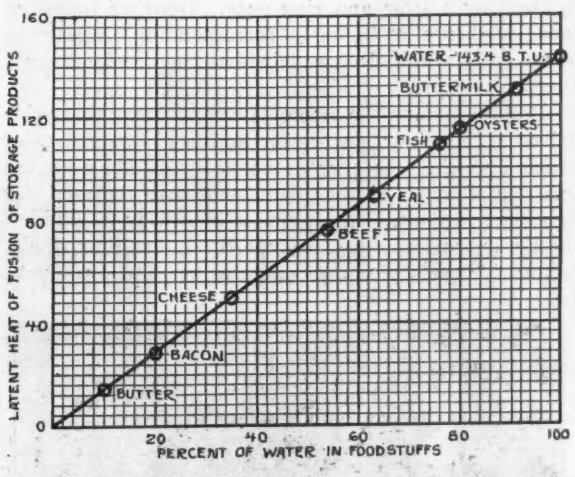


FIG. 3. CURVE COMPARING EXPERIMENTAL LATENT HEAT VALUES AND VALUES COMPUTED FROM PER CENT OF MOISTURE

Experimental latent heat values are shown in circles. Computed values of the latent heat are on the plotted line. The computed values are probably more nearly correct.

The plotted values of Fig. 3 show the latent heats of fusion reported from the several Bureaus of the United States and England. These were experimentally determined. The straight line shows the computed values on the basis of latent heat of fusion of water at the different percentages. The proximity of the experimental values to the values that would be found by computing them by multiplying the percentage of water within the commodity by 143.4 is evidence of the practical reliability of the computation method. Probably the computed values are the more nearly correct as experimental error is eliminated.

Specific Heat Values

In reviewing these values it will be seen that the specific heats of the fresh vegetables and fruits have been given as approximately 0.9. Refrigeration engineers seldom recognize that both vegetables and fruits give up what is termed by plant investigators as vital heat. By written communication to the author from the Bureau of Plant Industry, Washington, L. A. Hawkins, Physiologist, says:

"Vital heat is a term we have been applying to the

heat given off by living commodities through the life processes, such as respiration. This heat varies with the temperature of the commodity and the kind of commodity; for example, peaches give off considerable more heat at 75 deg. F. than do such fruits as apples and oranges. As far as I know, no careful calorimetric measurements have been made of the heat given off from the various fruits and vegetables at the various temperatures. According to Vant Hoff's law, the amount of heat given off by fruits and vegetables should increase two or three times for each 18 deg. F. rise in temperature. From this you can readily see that the calculation of the amount of heat it would be necessary to take out of fruits and vegetables in cooling them down is only an approximation, to say the least. For this reason, we believe that the usual method of calculating, using a factor of about 0.9 for specific heat, is probably as accurate as is necessary."

Diesel Oil Engine Replaces Electric Drive

Wiskow Ice Mfg. Co. of Baltimore Substitutes Oil Engine Power for Public Service Power in Ice Plant

ORIGINALLY the ammonia compressor of the Wiskow ice plant, which is of 40 t. ice making capacity, was driven by a 100-hp. electric motor geared to the flywheel by a spur and ring gear. Desiring increased capacity, hence requiring a corresponding increase in power, the former electric drive has been replaced by a Diesel oil engine.

Besides driving the ammonia compressor, this engine drives a 15-hp. air compressor and a 14-kw. generator which furnishes the current necessary to drive all the small auxiliaries of the plant and that required for lighting the plant. The engine is known by its builder, the Bethlehem Steel Co., as type S. It has four single-acting vertical cylinders, operates on the two-stroke

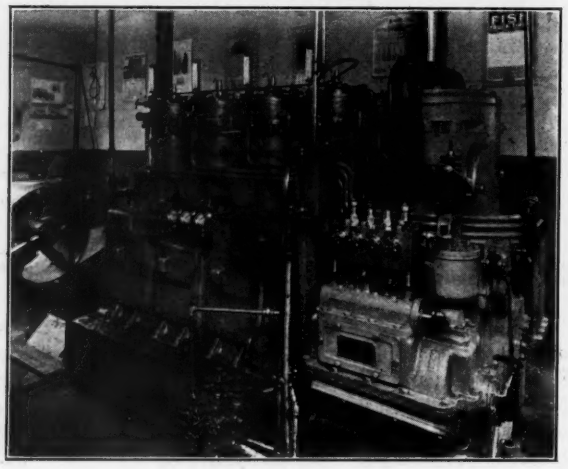


FIG 1. BETHLEHEM 120-HP. DIESEL OIL ENGINE INSTALLED IN WISKOW ICE PLANT

cycle and is rated at 120 hp. Figure 2 shows the transmission arrangement. An idler pulley makes possible the relief of the load in starting up the engine and, being located on the driven or loose side, increases the arc of contact on the engine pulley.

Port Scavenging Under Pressure Removes Burnt Gases

Charging and scavenging actions are indicated in Fig. 3, which shows the piston at its lower dead center. Scavenging air is admitted under low pressure into the cylinder from receiver A through port B, the air being deflected toward the head of the cylinder by means of curvature C in the piston. Burnt products are thus forced through exhaust ports D. As the piston covers the admission and exhaust ports, air is entrapped in the cylinder and compressed to about 500 lb. Fuel is then sprayed in through spray valve E, resulting in combustion, first in pre-combustion chamber F and then in cylinder at G. Pressure sufficient for rapid admission is given the scavenging air by the attached pump shown in Fig. 4, which is driven from a crank at the forward end of the engine crankshaft. This pump is double acting and is supplied with automatic pressure operated disk type valves. The air is drawn in through a muffler and discharged into the scavenging air receiver A, Fig. 3.

Forced feed lubrication is employed throughout the engine. Oil is delivered to the main bearings by an attached plunger type pump. A Manzel oiler is attached to the engine for lubrication of the power and scavenging pistons. This oiler is timed with the stroke so as to inject the required quantity of fresh oil at the proper time. A duplex strainer is installed in the oil line to clean the oil delivered to the system and an oil cooler is used to maintain proper oil temperature. A sump in the crank case forms a lubricating reservoir. Inside of the piston and just above the wrist pin at H, Fig. 3, a ring is cast to receive a plate which prevents any lubricating oil from splashing against the hot piston head and carbonizing there.

Precombustion Chamber Forms Rich Explosive Mixture

Fuel injection is accomplished by the Leissner system which combines the simplicity of airless injection with the advantages of the constant pressure cycle. The fuel injection pressure is approximately 1500 lb. per sq. in. The fuel pump, which is of the impact type, contains separate units for each engine cylinder and each plunger has its own suction and discharge valves. Each unit is provided with a cut-out valve, making it possible to cut off the fuel from any one cylinder. The fuel line to each cylinder may also be primed before starting so as to prevent air from entering the system. The fuel spray valve shown at A in Fig. 5 consists of an upward opening needle which serves as a simple check valve. When the fuel pump starts to operate, the pressure beneath the shoulder on the needle valve lifts the needle against the pressure of its spring. This allows the fuel to pass through the tangential slots in the lower part of the needle valve guide and through the orifice at the bottom of the spray valve to the pre-

combustion chamber which it enters in the form of a fine mist. The valve is closed sharply by the action of the spring when the fuel pressure is relieved by the opening of the suction valve in the fuel pump.

Combustion tubes, by reason of the limited amount of air which they contain, provide only partial burning of the fuel at this point thus forming a rich burning mixture with the air, which spreads through the holes in the tube over the whole combustion chamber.

Regulation is accomplished by the governor through a bypass system. A tappet operated through a linkage system from the pump tappet crosshead, opens the suction valve more or less according to the load on the engine, during the discharge stroke of the pump thus causing a portion of the fuel charge to be forced back into the supply. Altering the position of the end of the linkage system, which is accomplished by the governor, causes the tappet to strike the valve earlier or later in the plunger stroke.

Cylinder cooling is effected through the counter flow system, the coolest water first cooling the parts exposed to the gases of lowest temperature and then proceeding to the jackets of the hotter parts. Circulating water is delivered to a header which runs along the base of the cylinders. The water passes up through the jackets and then through jumpers to the cylinder heads. The method of providing cooling water for cooling the lower part of the fuel oil spray valve is shown at B in Fig. 5. Valves are provided on the discharge pipe from each cylinder head so that the flow of water through each cylinder can be separately regulated to insure the most efficient operating temperatures for any condition of load. Thermometers are provided in the cylinder heads to indicate the temperatures. The exhaust header is also water cooled so as to reduce the temperature and hence volume of the exhaust gases.

Starting is accomplished by means of compressed air. A manifold containing a valve for each cylinder is located at the forward end of the engine. When air is admitted to the manifold by the opening of the master valve, the pressure created closes all the valves in the manifold which are normally held off their seats by springs, except the valve to that cylinder which is in position to receive starting air. This valve is held open by the starting air cam which is attached to and timed with the camshaft. A check valve C, Fig. 5, is provided in the starting air line to prevent the cylinder gases from passing back into the line. This valve is inserted complete with its cage, in the cylinder head. The spring, which return the check valve to its seat on relief of the starting air pressure, and its washer and nut are in an external compartment, entirely separate from the incoming air, thus removing the danger of their passage into the cylinder in case of breakage.

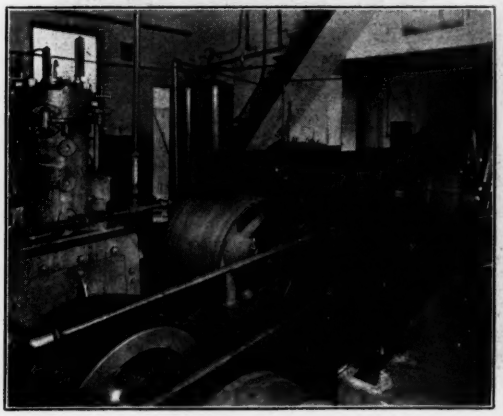


FIG. 2. ARRANGEMENT OF DRIVE SHOWING IDLER PULLEY AND MEANS FOR RELIEVING LOAD DURING STARTING OF ENGINE

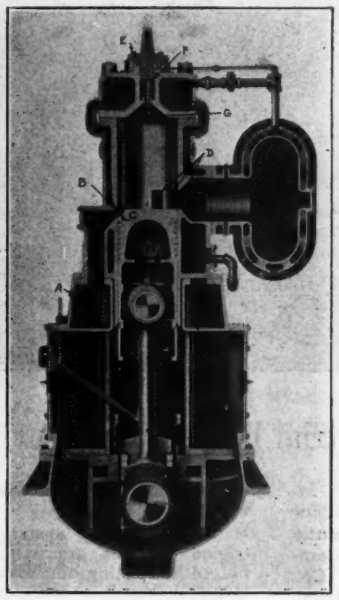


FIG. 3. SECTION THROUGH CYLINDER HEAD

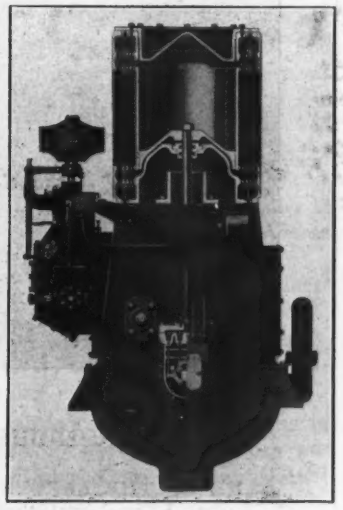


FIG. 4. SECTION THROUGH SCAVENGING PUMP. THIS PUMP IS DRIVEN FROM A CRANK AT THE FORWARD END OF THE ENGINE CRANKSHAFT

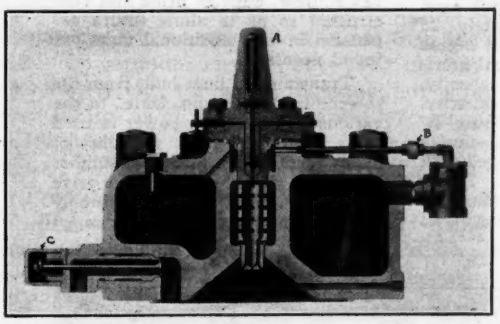


FIG. 5. SECTION THROUGH CYLINDER HEAD SHOWING FUEL SPRAY VALVE, PRE-COMBUSTION CHAMBER AND AIR STARTING CHECK VALVE

THE ARKANSAS POWER & LIGHT CO. is planning the construction of a new 110,000-v. transmission line 77 mi. long, extending from the Sterlington power plant of the Louisiana Power & Light Co., to Eldorado and Camden, Ark.

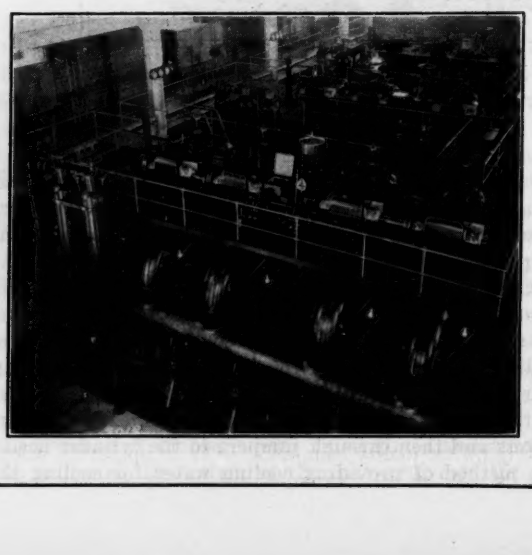
SOME PEOPLE don't study enough; other people study too much and think too little.

Large Industrial Diesel Plant Put in Service in Oklahoma

ONE OF THE LARGEST industrial Diesel installations for a number of years has recently been put in operation by the Commerce Mining and Royalty Co., whose headquarters are at Miami, Oklahoma. Three 2250-hp., 28 by 44-in., Nordberg, 4-cylinder, 2-cycle, air injection Diesels, direct connected to Westinghouse 2000-kv.a., 2300-v., 3-phase, 25-cycle generators, will supply power to 15 mills and mines operated by this company, as well as about 23 mi. of electric railway.

The lubricating system of each engine requires approximately 25 bbl. of lubricating oil. Each engine is supplied with an individual lubricating oil tank of 370 gal. capacity, and a fuel tank of 275 gal. capacity. Both air intakes and exhaust silencers are provided, the air intake of each machine being equipped with 18 units of Reed air filters. Direct connected 14-kw., 125-v. exciters are supplied with each engine and all auxiliary pumps are motor driven. The power house is 80 ft. wide by 125 ft. long, built of brick and constructed so as to allow future expansion in case additional units are found necessary.

Transmission lines built from the power plant at Gardin, Okla., to the various places where power is used make a network over a radius of about 14 mi., supplanting a number of smaller power plants which have previously been used to supply power to the various properties.



Great Lakes N. E. L. A. Discusses Problems at French Lick

FRENCH LICK SPRINGS Hotel at French Lick, Indiana, was the scene of the Seventh Annual Convention of the Great Lakes Division of the National Electric Light Association, September 22, 23 and 24. Several hundred members from four states, Illinois, Michigan, Wisconsin and Indiana, gathered there to discuss the problems of the electric light and power industry and, incidentally, to play golf.

Interesting papers were presented on many subjects —the public utilities' relation to the home, government ownership, home lighting, rural electrification, sales of power and appliances—all subjects of varied but intense interest. Women played an active part in the program, the papers of Mrs. Edward Franklin White of the General Federation of Women's Clubs and Miss Ruth Wardell, head of the Home Economics Department at the University of Illinois, being among the most interesting of the convention.

Mrs. White, in her talk on the Development of the American Home, presented the results of a survey of home equipment instituted by the General Federation of Women's Clubs. The equipment, which this survey covered, said Mrs. White, might be humorously classified as monotony relievers, drudgery killers and germ discouragers. The monotony relievers include autos, phonographs, radios and pianos. In the second class are washing machines, sewing machines, dishwashers, vacuum cleaners and refrigerators. Germ discouragers include water, sink drains, bath and laundry tubs. While many interesting facts regarding the use of these various pieces of equipment were disclosed, the most significant was that the American people own more radio sets and autos than bath tubs and vacuum cleaners. Even in villages the kitchen sink is less in use than the automobile. The germ discouragers have their innings in cities between five and a hundred thousand, but it looks, said Mrs. White, as if this is a matter of compulsion in health, for where there is greater freedom of choice, this choice goes to the automobile instead of the bath tub.

Public relations, as always, was a point of considerable discussion at this meeting and J. F. Owens of Oklahoma City, who is chairman of the Public Relations Section of the N. E. L. A., delivered the keynote address on this subject. Mr. Owens pointed out that although excellent work had been already accomplished on the question of public relations, it was a job that would never be finished and one that required eternal vigilance.

In regard to the question of public ownership, which a certain element in the United States is always advocating, the Boulder Dam project on the Colorado River is a situation with which the N. E. L. A. is definitely concerned and this project was one of considerable discussion. The principal speaker on this question was Charles A. Eaton, member of Congress from New Jersey.

Another address of great interest was that delivered by Miss Ruth Wardell, head of the Department of Home Economics at the University of Illinois. Miss Wardell offered a wealth of constructive criticism on the policies of many public utility companies in their appliance sales methods. When all companies are trying to raise their residential load, it is all very well to state that the average kilowatt consumption of about 400 kw. a year should be doubled and tripled, but in doing so the fact that 55 per cent of the incomes in the United States are of $1500 and less must be kept in mind. In the sale of appliances, the housewife of America must be given more information whereby she may effect an intelligent selection of such appliances. Standards of performance should be made available and information in regard to installation and operation costs should be provided. The housewife, said Miss Wardell, has no recourse to the methods used by industries in buying equipment—that is, the expensive electrical appliance which she is now urged to buy. In the case of a 25-cent egg beater, she could junk it if she found it unsatisfactory, but if after paying $300 for an electric refrigerator or $65 for a vaccum cleaner or $125 for a washing machine, she finds it unsatisfactory, she cannot afford to discard it and purchase new ones. These, said Miss Wardell, are problems of the utility and manufacturing companies and it is their function to solve them if they expect to sell the appliances and create the electrical load they desire.

Other papers of interest covered Home Lighting, Use of Electricity in Agriculture, Relation of Radio to Electric Utilities and Effect of Regulation on the Management of Public Utility Enterprises.

At the annual banquet on Thursday, the speakers were H. T. Sands, president of the National Electric Light Association and Paul S. Clapp, executive manager, N. E. L. A., with Thomas T. English, president of the Great Lakes Division, acting as toastmaster.

On Thursday night, after receiving the returns of the Dempsey-Tunney fight by radio, the audience was privileged to hear C. M. Ripley of the General Electric Co. deliver an address entitled "Advantages in the U. S. A. vs. the World."

G. E. Develops Vacuum Tube Synchroscope

VACUUM TUBES, developed primarily in the field of radio, have now been applied in an entirely different field—that of a vacuum-tube synchroscope.

The first installation of this new type of equipment was made by the General Electric Company at the Menands substation of the Adirondack Power and Light Corporation, near Albany, N. Y.; the second was made on the system of the Metropolitan Edison Company of Reading, Pa.; and the third installation is now being made at Ocoee Plant No. 1 of the Tennessee Electric Power Company, 60 miles from Chattanooga.

This vacuum-tube synchronizing equipment provides the usual "fast," "slow," and "synchronism" indications without the use of instrument potential transformers. Potential from the lines to be synchronized is obtained from a capacitance transformer, and is amplified by means of vacuum tubes until sufficient power is obtained to operate a synchroscope.

Standard oil-filled bushings of transformers, oil circuit breakers or other apparatus can be replaced by a modified bushing with capacitance transformer for furnishing potential to the vacuum-tube apparatus. Where such bushings are not in use, the capacitance trans-

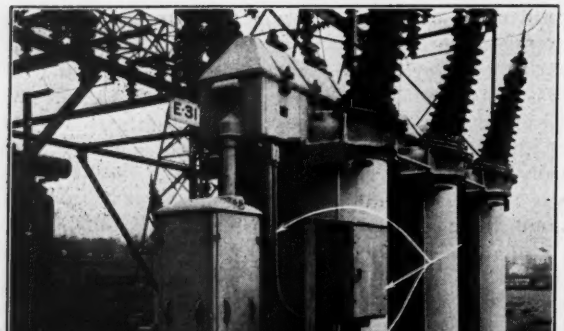


FIG. 1. VACUUM TUBE SYNCHROSCOPE INSTALLATION AT THE MENANDS SUBSTATION, ADIRONDACK POWER & LIGHT CORP. ARROW INDICATES OUTDOOR UNITS AND LEADS

former can be supplied in a separate tank which can be installed either outdoors or indoors. The voltage obtained in this way is in phase with the line-to-neutral voltage of the system. A capacitance transformer must be provided at each point where a potential transformer would be necessary if transformers were used for synchronizing.

The potential obtained from the capacitance transformer is impressed on the grid-filament circuit of a vacuum tube and amplified. This tube should not be more than 50 ft. from the transformer. The low-power amplifier is built into a weatherproof housing for outdoor mounting. One such amplifier is required for each bus and line to be synchronized. The low-power outdoor amplifiers require a five-wire multi-conductor cable with 500-v. insulation between the amplifier and the substation where the high-power amplifiers are installed.

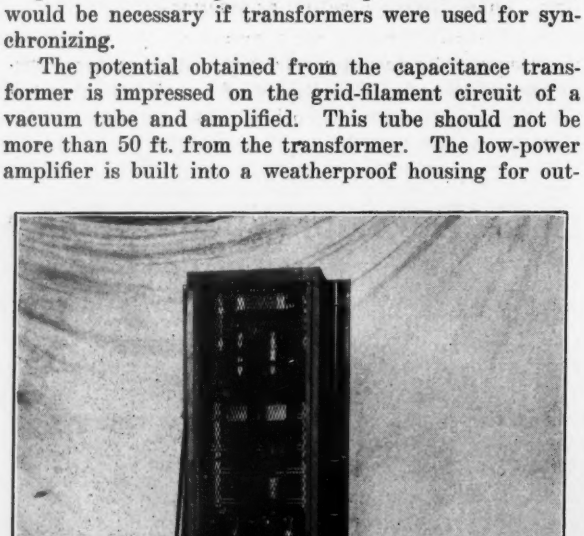


FIG. 3. REAR VIEW OF 50-W. AMPLIFIER PANEL OF VACUUM TUBE SYNCHRONIZER

Station equipment consists of a tube and control unit, a motor-generator set, and the synchroscope. The tube and control unit consists of two 50-watt amplifying tubes and their associated equipment. These tubes will amplify the energy received from the low-power amplifiers sufficiently to operate the indicating synchroscope. The high-power amplifying equipment will take care of any number of synchronizing points at one substation. Proper switching means are provided to take care of a number of circuits where this is necessary. The motor-generator set consists of a driving-motor, a filament alternator, a bias generator, and a high-voltage double-commutator generator. The driving motor requires approximately 1000 watts and operates from the station battery, or, with a different type of motor,

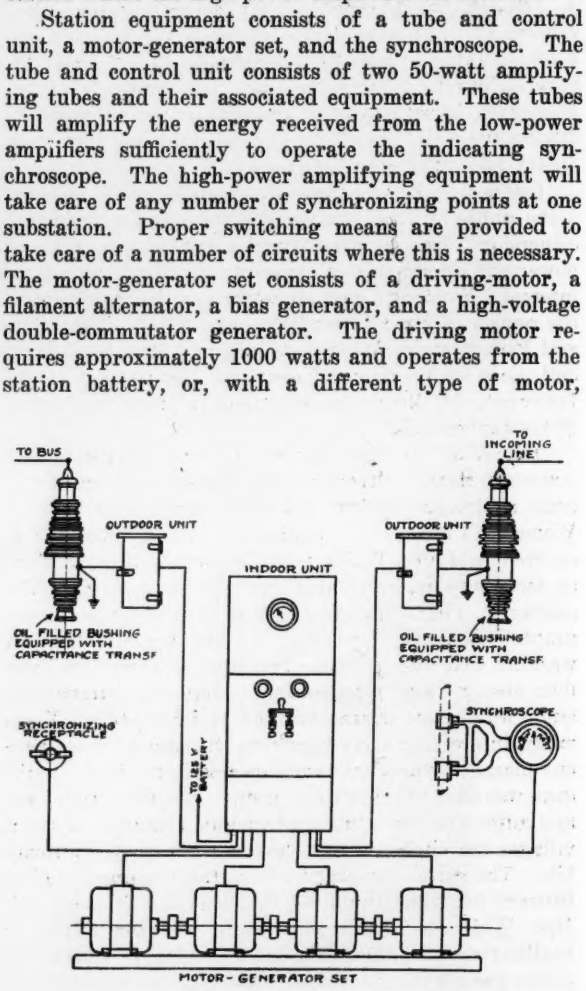


FIG. 2. SINGLE LINE DIAGRAM OF EQUIPMENT

alternating-current can be used. The filament alternator supplies the filament excitation for all the tubes. The bias generator supplies bias potential for all the tubes and excitation for the high-voltage generator, which supplies direct-current at 500 and 1000 v. for the plate supply of the amplifiers.

Insertion of the synchronizing plug starts the motor-generator set, which lights the tube filaments and supplies all necessary power. The synchroscope operation is the same as if potential transformers were being used. Where there are several lines to be synchronized, the connections are alternately transferred to the indoor unit or power amplifier so that only one indoor unit is required.

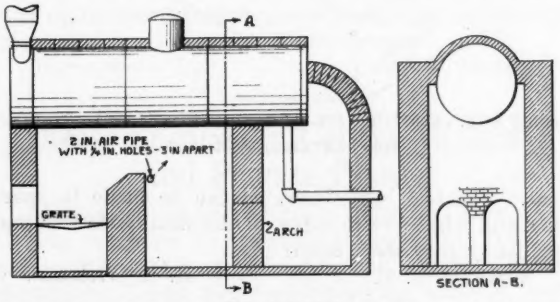
All tubes for high-power amplification and the accompanying transformers, grid bias, resistors, voltmeters, fuses, generator-field rheostats, motor starter and power switch are mounted on the indoor panel, which can be placed in any convenient location in the station.

LETTERS DIRECT FROM THE PLANT

Supplementary Air Betters Combustion

LOCATED as we are in the heart of the business district of a good sized town and burning bituminous coal which contains a high percentage of volatile matter, we had our smoke problem. In order to overcome this and to raise the economy of operation, the devices illustrated herewith were installed. The cost was small but the results large.

Our boilers are hand-fired return tubular boilers operating under natural draft. A 2-in. pipe in which ¼-in. holes were drilled 3 in. apart was installed just behind the bridgewall low enough to be sufficiently protected from heat and so placed that the supplementary air entered the combustion chamber at the angle indicated in the illustration. The pipe extended through



PERFORATED PIPE FOR SUPPLEMENTARY AIR AND COMBUSTION ARCH FOR MIXTURE CAUSE REDUCTION OF SMOKE AND INCREASE IN ECONOMY

the walls of the settings so that the air was drawn in at these points at the sides of the boiler.

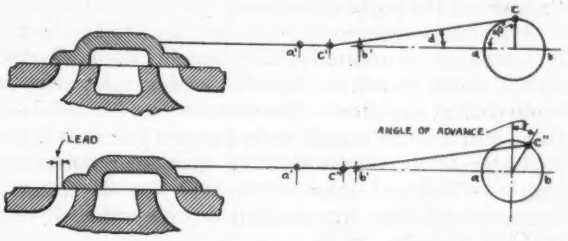
Everything back of the bridge well was removed and a combustion arch of fire brick, shown in the illustration, built halfway between the bridge wall and the rear wall. This arch caused the gases and supplementary air to mix more thoroughly and helped to maintain a high temperature in the combustion space. As the gases were burned before reaching the cooler parts of the boiler, smoke was not formed.

Pleasant Hill, Mo. G. H. BROUGH.

Determination of Proper Length of Eccentric Rod

THE QUESTION asked on page 850 of the August 1 issue is ambiguous: It has three possible meanings. In the first place it sounds like a design problem and, as such, the length of the rod is governed by the length of the engine or by convenience, for though one or even two rocker arms were used, the length of the rod would still be so long in proportion to the throw of the eccentric that the question of valve motion distortion would not enter.

The question can, however, be taken as Mr. Mason suggests in the September 1 issue; that is, how to measure the length of the rod. In this case it can be answered very simply by the use of a folding rule or steel tape. If you want only the distance shown on the sketch published, it is exceedingly simple; if you want the distance clear to the center of the eccentric, it is



PROPER LENGTH OF ECCENTRIC ROD ADJUSTED BY MEANS OF RELATIVE POSITIONS OF ECCENTRIC AND VALVE

necessary to get the throw of the eccentric and add the proper correction to the measurement taken up to the shaft.

Why is it necessary to go to the trouble of putting the valve in mid-position? That rod is of fixed length, adjustable, it is true, but fixed for each adjustment so that the length is the same regardless of the position of the valve. Of course, knowing Mr. Mason's familiarity with engines, it is foolish to suppose that he did not know this. Possibly he was assuming that an engineer was setting valves, knew the length of the rod and was just laying it out, in which case the valve and eccentric would be put in the position mentioned as a matter of course in setting the valves. Perhaps the question would have been clearer if stated something like this: "If an engineer were setting the valves of an engine, how would he determine how long to make the eccentric rod?"

This can be found as follows: Turn the eccentric to one of its extreme positions a or b, see illustration, and adjust the length of the eccentric rod so that the end a^1 or b^1 comes near one end of the slider, then turn the engine over until the eccentric is at the other extreme end and locate the point c^1 midway between a^1 and b^1. When c^1 has been located, turn the crank to either head or crank end dead center and then, without turning the shaft, slide the eccentric until the end of the rod is at c^1. The eccentric is now 90 deg. ahead of the crank. Not exactly 90 deg., but as the editor so clearly explained, the angle d is so small that the error introduced is too small to be considered.

With the eccentric and shaft stationary, the length of the rod should be adjusted so that the end, that is point

c^1, is in the middle of the slider, or if a rocker arm is provided, the length of the eccentric rod should be such that the arm is vertical. The valve should then be placed in its mid position and the valve rod adjusted and connected to the eccentric rod, rocker arm or slider, as the case may be. The valve and eccentric are now both in mid position, and the junction of the two rods is at the middle of the slider. Then the eccentric is slid ahead to give the proper angle of advance. If the lead is known, slide the eccentric ahead until the valve is open a distance equal to the lead, i.e., the distance the valve is open and when the crank is on dead center. If the lead is not known, try about $\frac{1}{32}$ in., then use an indicator.

Eccentric rods on Corliss engines are set in the same manner. If there are two rocker arms with a reach rod between, the reach rod, eccentric rod and valve rods should all be set so that the rocker arms are vertical when the valve and eccentric are in mid position. The lead can be measured, not directly, as with a D valve, but from marks at the end of the valve showing where the edges of the ports are located.

After the rods have been set and the setting checked by means of an indicator, they should all be marked with a center punch so that the setting can easily be duplicated at any time. These marks can be made any distance apart and a gage made for each one; but it is a good plan to make them 6 in. or some other convenient length so that one gage will answer for all and any changes made either intentionally or unintentionally can be detected easily.

Los Angeles, Calif. B. MARKER.

Dry Pipes Need Attention

ON PAGE 949 of the September 1 issue is an article on the above caption to which I take some exception.

Choking up of the perforated holes in a dry pipe with scale and dirt usually indicates neglect on the part of the operator. Dry pipes should be provided with clean-out plugs which should be removed whenever the boiler is washed out, at which time the dry pipe should be scraped, washed out and inspected for choking up of the perforated holes. If dirty water is used, this inspection and cleaning must be proportionately more frequent. Foaming is usually caused by dirty feed water or forced firing of a boiler that has small steam capacity or steam liberating surface.

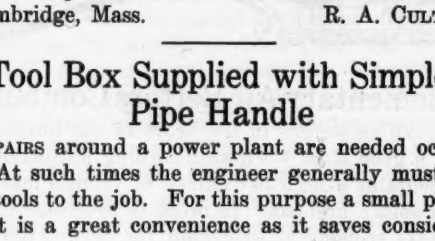
Use of a triple duty stop valve on each boiler as suggested by Mr. Jordan is flirting with disaster. If the valve would automatically close and stop the escape of steam through the steam line, the power to the engines would be automatically cut off and the entire amount of surplus steam in this boiler would have to escape through the safety valve, thus increasing the possibility of foaming if the water level at that instant happened to be a little high. The sudden reduction of pressure in such a small steam space would cause water to be forced up in large quantities into the safety valve choking the outlet and causing breakage if not the blowing off of the valve entirely, due to the water hammer action which would be thus caused. If the perforated holes become choked up, the water which would collect in the pipe due to the wet steam being delivered to the engine, would be carried over in a slug endangering the engine.

Dry pipes are used where the steam space and steam liberating surface are very small. In such cases it is best to carry the water level as low as safety will allow to prevent the water from being carried over in the form of spray. Carrying the level at about one-quarter of the height of the gage glass, works well under these conditions. A separator should be installed near the engine to trap this water out of the main.

Cambridge, Mass. R. A. CULTRA.

Tool Box Supplied with Simple Pipe Handle

REPAIRS around a power plant are needed occasionally. At such times the engineer generally must carry a few tools to the job. For this purpose a small portable tool kit is a great convenience as it saves considerable



SHORT PIPE LENGTHS AND ELLS FORM CONVENIENT HANDLE FOR PORTABLE TOOL BOX

time. The tool box illustrated can be made in spare time and will serve to carry all the small tools required for the average short repair job.

Syracuse, N. Y. H. L. WHEELER.

Make Damper Control Convenient

AN ENGINEER of a small isolated steam plant had tried without much success to have his fireman close the damper whenever the furnace doors were opened for replenishing the fire. The fireman simply could not be depended upon to walk to the damper control before opening the furnace door and upon several occasions, when the damper had been duly closed, the fireman had forgotten to open it again after stoking the fire.

Determined to remedy this trouble, the engineer brought the damper control right to the fire door, making the opening and closing of the damper so simple and easy that it would not be overlooked. Unfortunately as this little steam plant was of "home-grown" variety, if the engineer desired improvements, he must make them himself and beg the material necessary for the work.

From various sources of discarded material, the engineer was able to acquire two light 10-in. sheaves and two others slightly smaller, some light flexible wire cable, a 3-ft. bar of ¼ by 1½-in. steel and some small articles such as a coiled spring, a stud-bolt 6 in. long, which could enable him to mount the four sheaves in required positions. One of the larger sheaves was attached to the stem of the damper and made fast in such

a position that the sheave would run true, both in the plane of its axis and sidewise. The other large sheave was fitted to the long stud-bolt which had been drilled and tapped into one of the doors covering the tube ends. The piece of bar steel had been fastened to one side of this sheave as a handle whereby to rotate the sheave after it had been mounted upon the stud bolt with the coiled spring between the nut and the sheave. Sufficient tension in the spring was secured by screwing down the nut until the friction of the sheave against the boiler front would hold the sheave and its attachments in any required position between wide open and fully closed.

The piece of small, flexible cable was then placed upon the damper sheave and fastened by clinching the cable around a small stove bolt after passing it through a hole drilled in the sheave for that purpose. The cable thus fastened to the damper sheave was given a complete turn around the sheave, then both ends of the cable were led to the sheave upon the boiler front, the pair of smaller sheaves having been so mounted as to support the cable in such a manner that it was properly guided from the damper sheave to the sheave upon the boiler front.

After the apparatus had been fully adjusted, the sheave handle was located close to the fire doors, enabling the fireman to operate the damper from his stoking position by simply moving the sheave handle and no further trouble was experienced in the attention given to damper operation by the fireman.

Indianapolis, Ind. JAMES F. HOBART.

Diesel Engines in Central Stations and Private Plants

ENGINEERS will be grateful to John M. Drabelle and to your magazine for the enlightening article from his pen entitled "Diesel Engines from Central Station Standpoint," and your accompanying editorial comment in the September 1 issue.

Notwithstanding the reluctance of many electric power companies to encourage the use of oil engines, a number of the more progressive central station systems have found it advantageous to enlist them in their own service. This too, notwithstanding the fact that central station usage generally denotes a low load factor under which the fuel economy of the oil engine is partially discounted by heavy overhead charges. Considerable significance is attached to your remark that of the 28 steam and 12 Diesel units owned by the company mentioned, a considerable number of the smaller steam units are being used only as standby units when taking power from transmission lines, but all of the Diesel engines are in service. Recent statistics show that electric central stations represent one of the largest classes of Diesel engine users, having installed about 18 per cent of the total horsepower manufactured. Diesel engines seem to be gaining rapidly in popularity with the central stations, 100 per cent more Diesel horsepower capacity having been purchased by them in 1925 than in the year before, and 500 per cent more than in 1920.

Better use of oil engines, however, can be made by industrial power plants than by central stations. An oil engine power plant to serve a private concern can be built for less money and can be run at less expense than if owned by a public utility. For this reason, the power user who is thinking of installing an oil engine power plant should modify, according to his own conditions, the cost figures occasionally published for central station plants.

Buildings for public utilities are, almost without exception, far more expensive than for private power plants because of the desirability of giving them an advertising value. The electrical equipment in an industrial power plant costs less because of much simpler switching arrangements and the absence of transformers. Then again, public utilities are accustomed to charge into their installation costs such items as interest during construction and overhead, items that are seldom involved in the building of private plants. Because of these and other differences a 400-kw. oil engine generating plant for private use can be built for about $150 per kw. instead of $220 to $250, as given by Mr. Drabelle for a central station.

Operating costs are less in the private plant mainly because of the lower costs, on a kilowatt-hour basis, of labor and fuel. The 900-hp. Diesel station set forth by Mr. Drabelle produced 833,071 kw-hr. a year, corresponding to an annual output factor of only 15.8 per cent. If this were a factory power plant operating 300 days a year, 8 hr. a day at 75 per cent of rated load, the output would be 1,080,000 kw-hr. a year, or about 30 per cent more than when used as in a central station. The payroll itself would also be less in the private plant because of the fewer running hours, and thus the labor cost per kilowatt-hour produced would be considerably reduced.

In most industrial plants the load is much more uniform than in a central station. This leads to fuel economy and also lower maintenance expense. In many central stations the daily load curve shows fluctuations ranging from 10 or 20 per cent load to full load or even overload. While this may figure out to an average load of say 70 per cent, the engine conditions are not nearly as favorable as in a factory power plant where the same average of 70 per cent may be obtained from fluctuations through a narrower range, say 50 to 90 per cent.

An oil engine uses practically the same amount of lubricating oil, no matter what load it is carrying. Since the engine runs fewer hours in a private plant for the same energy output, less lubricating oil will be used per unit of output.

Despite the unfavorable conditions, the 900-hp. Diesel central station mentioned before showed a total operating and maintenance cost of 1.72 cents per kw-hr. It is probable that under the operating conditions of a private plant, this cost would have been about 1¼c., and figures obtained from such plants justify this conclusion. At the rates commonly charged for electric power it would take but 4 or 5 yr. for such a private plant to pay for itself.

If oil engines are making good in central station work—and the evidence points that way—the industrial power plant should keep in sight its own opportunity to use them to still better advantage.

New York City EDGAR J. KATES.

It is not clear why installation costs in private plants should not include such items as interest during construction and overhead, as stated by Mr. Kates.—EDITOR.

QUESTIONS AND ANSWERS

Steam Consumption Calculated from Indicator Card

WILL YOU PLEASE tell me how to figure the steam consumption per horsepower hour in pounds for the enclosed indicator card? C. R. S.

A. Calculations of the water rate from indicator cards are approximate and the result should not be used

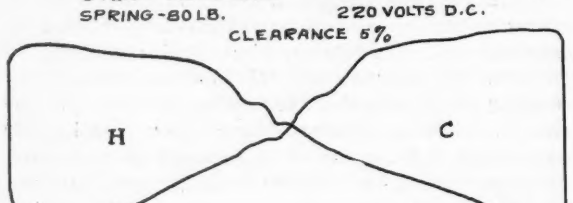


FIG. 1. INDICATOR CARD TAKEN OF 12 BY 36 SIMPLE STEAM ENGINE RUNNING AT 122 R.P.M.

except as a very rough estimate. There is only one accurate method of obtaining this figure, and that is by weighing the exhaust from the engine.

Most approximations or calculations are based on the amount of steam in the cylinder at release with a certain allowance made for condensation. This allowance is an experimental determination derived from other tests.

In this case this method could not be used because release is practically indeterminate at either end. We can, however, use equations which deal entirely with the cutoff and compression, later make corrections for condensation by means of experimental equations and data

$$K=(13{,}750\div \text{M.E.P.})\ [(z+c)-(x+c)P_2\div P_1]d$$

Where K = indicated steam in lb. per i.hp., z = fraction of stroke completed at cutoff, c = clearance in per cent of stroke, x = compression in per cent of stroke, P_1 = initial pressure in lb. per sq. in. absolute, P_2 = exhaust pressure in lb. per sq. in. absolute, d = density in lb. per cu. ft. at initial pressure.

The above formula gives the indicated steam and to this must be added what is known as the missing water. The missing water, which we will call M is given by the following equation:

$$M = (0.27K \div \sqrt[3]{N})\ \sqrt{s\ (x_2 - x_1) \div P_1 Z}$$

where N = r.p.m., s = ratio of cylinder displacement surface in sq. ft. to the displacement in cu. ft., x_1 = constant for P_1, x_2 = constant for P_2.

s can be calculated from the equation

$$s = (2 \div L) + (D \div 48)$$

where D = cylinder diameter in in.; and L = stroke in feet.

Constants x_1 and x_2 can be determined from the curve shown herewith.

From the card Z = 0.31, x = 0.16, c = 0.05, P_1 = 135 + 15 = 150, P_2 = 20 and the M.E.P. = 79. From the steam tables D = 0.332 so that

$$K=\frac{13{,}750}{79}[(0.31+0.05)-(16+0.05)\frac{20}{150}]0.332=19.1$$

Substituting the proper values of L = 3 and D = 12 in the equation

$$s=\frac{2}{3}+\frac{12}{48}=0.92$$

From the curve x_2 = 300 and x_1 = 220 so that

$$M=\frac{0.27\times 19.1}{\sqrt[3]{122}}\sqrt{\frac{0.92\ (300-220)}{150\times 0.31}}=1.3$$

Adding 19.1 and 1.3 gives a total of 20.4 lb. of steam per i.hp-hr.

As the electrical output of the generator is given, the engine efficiency and steam per kw-hr. can be calculated if a generator efficiency is assumed. Taking the generator efficiency as 80 per cent the br.hp. delivered by the engine is

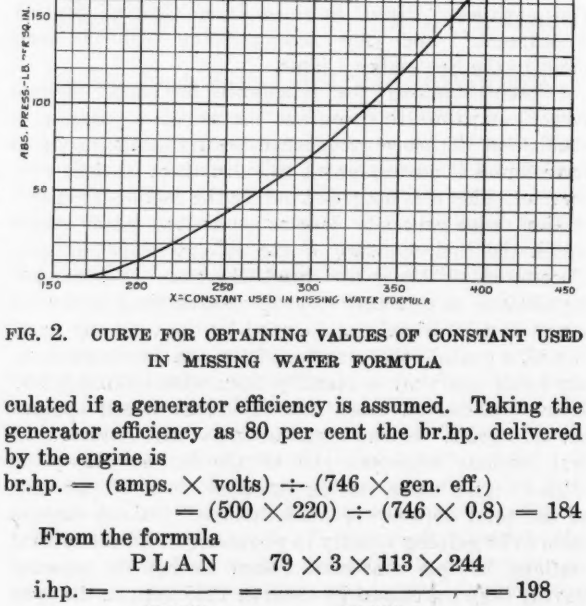


FIG. 2. CURVE FOR OBTAINING VALUES OF CONSTANT USED IN MISSING WATER FORMULA

br.hp. = (amps. × volts) ÷ (746 × gen. eff.)
= (500 × 220) ÷ (746 × 0.8) = 184

From the formula

$$\text{i.hp.}=\frac{PLAN}{33{,}000}=\frac{79\times 3\times 113\times 244}{33{,}000}=198$$

Therefore, the mechanical efficiency of the engine is

$$\frac{198}{184}=92.7 \text{ per cent.}$$

The combined efficiency of the

engine and generator is 80× 92.7 = 74.2 per cent and the pounds of steam per kw-hr. would be 20.4 ÷ 74.2 = 27.5.

A simple rule that can be used in some cases to give a rough approximation of the indicated water rate is to multiply the percentage of the cylinder volume that is filled with steam at release by the weight of a cubic foot of steam at release pressure. Multiply this by 137.5 and divide by the m.e.p.

Change to Condensing Improves Pumping Engine

WE HAVE SIX horizontal cross compound 24 and 40 by 7½ by 36-in. pumping engines working against a pressure of 600 lb. Steam is supplied to the high pressure cylinder at 140 to 150 lb. The valve gear is of the Meyer riding cutoff type with two eccentrics on each side of the flywheel. At present the above engines are operated non-condensing with a back pressure of about 7 lb. As we have no use for the exhaust steam we would like to know whether it is possible to make them condensing by the addition of a condenser. Can the Meyer valves on these pumps be set to work at a vacuum? What changes or alterations in the valve gear are necessary, and how should they be set to obtain the benefit of the vacuum? C. R. L.

A. Assuming that all conditions are the same except that the back pressure would be removed and the engine exhaust into a 26-in. vacuum, we can see no reason why this could not be done satisfactorily. With the present high pressure cylinder, however, and 1/3 cutoff, you would get only about five expansions and would not be able to take full advantage of the vacuum nor divide up the load between the high and low pressure cylinders.

By replacing the old piston and cylinder with one 20 in. in diameter or rather getting a new 20-in. piston and putting a liner in the old 24-in. cylinder your cylinder ratio would be improved and you could also have a steam jacket space between the old liner and the present cylinder walls which should tend slightly to increase the efficiency. At 1/3 cutoff this would give you 12 expansions. The Meyer gear can easily be set to 1/3 cutoff or less and as the vacuum will have no tendency to lift the valves off their seat, there is no reason why these engines should not be changed.

In order to get proper compression at the lower pressure ranges at which the cylinders would operate, it would be necessary to increase the angle of advance by showing the main eccentric ahead. This would give earlier compression and admission and later release. Probably no change would be needed in the cutoff eccentric beyond changing the lap. If this is necessary, however, decreasing the angle of advance of the cutoff eccentric will bring the range of cutoff closer to the original value.

Hot Water Lifting Affected by Valves

CAN A DIRECT-ACTING steam-driven vacuum pump lift water at 160 deg. a height of 6 ft.? This is in a steam-heating system, the pump being located in the boiler room some distance from the building to be heated. The vertical lift is 6 ft. and the pipe line has two 90 deg. elbows. Some engineers say it can be done and some say it cannot be done. A. K.

A. Speaking generally, we believe both answers to be correct, assuming, of course, that the pipe line is large enough so that friction loss is small. Theoretically 160 deg. water can be lifted about 23 ft. It is generally stated, however, that the maximum lift attainable under favorable conditions is about 5 ft. at 165 deg. while for dependable service, such as boiler feed work, it is best to have no suction lift at all at this temperature. These figures are, of course, for sea level. Altitude has a considerable effect. For instance, a boiler feed pump handling 190 deg. water at sea level should have a positive suction head of about 7 ft. This should be increased approximately 1 ft. for each 1000 ft. elevation.

With proper size pipe, we would say that the answer to your question depends entirely upon the pump being used. If the valves are too heavy or too heavily spring loaded, you would undoubtedly have difficulty but, with proper valves, or with a rotary or centrifugal pump properly installed, you should have little difficulty. If the temperature runs considerably above 160 deg., it would be advisable generally to install some kind of an overflow to the sewer, so that if the pump should lose its suction, no damage would be done by the water in the basement of the building to be heated.

Odd Sized Shafting Due to Former Method of Manufacturing

WHY IS shafting made $\frac{1}{16}$ in. under even sizes instead of even sizes; that is, why is it not 2 in. in diameter instead of $1\frac{15}{16}$ in.? J. G. M.

A. Originally shafting was made of wrought iron and hence it was necessary to turn it off in order to have it smooth and of exact size. The allowance for this cut was about $\frac{1}{16}$ in., using stock of even size.

Today cold rolled steel is used instead of wrought iron. No turning off is required in this case because the rolling process makes it both smooth and true to size. In fact it is best not to turn it off because the outer surface is harder than the inner material due to the rolling process in which the surface is burnished.

Since the odd sizes had been in use so many years and so many pulleys had been made in these sizes, cold rolled shafting was at first made exclusively in the odd sizes, but now the steel as well as pulleys may also be obtained in regular even sizes.

Efficiency of Boiler Ligament

IS THERE ANY RULE for determining the minimum ligament to be used between tubes in the head of an h.r.t. boiler or is this left to the designer? A. M. C.

A. If p = pitch of tube holes in in. and
d = diameter of tube holes in in.

$$\text{the efficiency of ligament} = \frac{p - d}{p}$$

If this quantity is multiplied by the tensile strength of the boiler plate, the computed strength of the portion drilled for the tubes is obtained. If this strength is lower than the strength required by the authorities in any particular location, the pitch must be proportionally increased.

EDITORIAL COMMENT

Forecasting Success in Engineering

"This is the time of year," says a syndicated column of opinion in one of our daily newspapers, "when thousands of young men and boys are considering very seriously for what their school work is going to prepare them." (We presume to doubt it, having some interest in the baseball situation ourselves, not to mention our concern with the 1927 football schedule at dear old Whoozis College.) However, the writer continues: "If I had a boy of high school age who had a marked liking for mathematics and mechanics, I would encourage him to look forward to a career in engineering."

Seriously speaking, we wish to raise several questions in regard to this statement. The writer of it might be justified in saying that a boy with a marked liking for mathematics and mechanics may look forward to an engineering career, if he were careful to point out also that mathematics and mechanics are two of the most useful tools the engineer possesses, but that he must also possess other things. Many people, however, mistake the using of the tools for the practice of the profession. As every engineer knows, there is a great difference.

Does a marked liking for these two fundamental sciences really indicate possession of engineering ability, or does it merely indicate ability to think clearly and a certain skill in co-ordination of hand and brain? These two qualities are involved in the equipment of a great pianist, as much as in that of a great engineer. Does it necessarily follow that the boy who is constantly tinkering with a radio set or with the family car is a born engineer? Or is it possible that he is just satisfying an instinctive longing to make something with his hands and that he really will turn out to be a great sculptor? It has been our observation that there is absolutely no way to tell. Yet many boys select engineering as a career, or are advised to do so, on no other basis.

We believe that much of the trouble our engineering schools have today is caused by this loose generalizing about the engineering aptitudes of boys with a liking for mathematics and mechanics. After a couple of years in an engineering school, many boys of this type discover that their real ability and interest are not in engineering at all, but in biology or other sciences or perhaps in one of the arts requiring this power of logical thinking and some manual skill. They often hesitate to make a change, however, fearing the scorn of friends, family and instructors, and hating to seem lacking in tenacity of purpose. So they continue in engineering, only to become permanent misfits.

Mathematics and mechanics are pure sciences in themselves and are only two of the tools the engineer must master. True, to be an engineer he must master them but he must also master many others. In addition, he must possess mental and moral characteristics that are usually inborn and impossible of acquisition. He must have, in short, the engineering type of mind.

At the risk of being challenged to mortal combat with axes at forty paces, we feel that we must question the truth of this opinion, held so generally by the non-engineering public, that liking for and proficiency in the sciences of mathematics and mechanics, regardless of his other qualities, are certain indications of a boy's future success as an engineer.

The Heart of Our National Industrial Development

Speaking in Philadelphia not long ago, Dexter Kimball, Dean of Sibley College of Engineering of Cornell University, said, "Industrial development has progressed along three well defined lines, mainly: labor saving machinery, time saving machinery and machinery for transmitting intelligence. All three of these lines of endeavor have occupied men's minds from time immemorial but it has remained to engineers within the last century and a half to make machinery and scientific apparatus to revolutionize not only our manner of living, but our idea of existence as well."

Behind all this development is power—first water power, then steam, and later electricity. Commercially, the basis of all our developments is power plant engineering, and we may even go so far as to say that the birth of our present industrial era was the original Pearl Street Station of New York City, the first central station. At present our entire scheme of existence is tied up with the production and use of electricity and indications are that future developments will probably be along the same line.

Although directly applied steam or water power brought the development of labor saving machinery to a high plane and resulted in considerably improving time saving machinery, it was only with the advent of commercially practical electricity that machinery for transmitting intelligence was produced and the other two brought to their present high stage of development.

We suspect that, for the sake of sentiment, Dean Kimball extended the development period to 150 years rather than narrowing it to the last 50. With all due respect to the efforts of the early scientists and engineers whose work made the present era possible, it was and is the practical application of these ideas which has been directly beneficial. Unlike art, architecture and kindred fields, we look forward into the future for inspiration rather than back to bygone ages.

As an industry we know from personal experience what has been accomplished, what is being accomplished, and can look forward to what will be accomplished. The industry has been born, has reached almost unbelievable

heights in the short space of a simple human lifetime and still has a future none can even guess. All branches of engineering, mechanical, electrical, chemical, metallurgical, structural, hydraulic and civil, even the so-called financial and commercial engineering, have played their part so that even modesty does not enjoin us from saying that no greater tribute to engineering as a whole could be given than a national or world-wide appreciation of the heart of our modern industrial development —the power plant industry.

Off Duty

Electricity, it must be admitted, even by those who are qualified to speak of it knowingly, is a strange thing and its action quite often mystifying, but its antics are never so charmingly unique as when portrayed by the versatile knights of the press. For the newspaper boys have imaginations—they are not restrained nor hampered by such obvious absurdities as Ohm's law and their interpretation of electric phenomena naturally takes on an aspect of mystery and romance never to be found in the literature of electrical engineering. In electricity the reporter sees something eternally spectacular. The tiniest electrical discharge to his mind is always a bolt of artificial lightning. A Coolidge cathode ray tube in the newspapers instantly is converted into the "Coolidge Death Ray" tube with sinister possibilities.

Consider, for instance, this choice morsel under the startling heading "Proves to Radio Fair Crowd That Electric Chair Can't Kill Him," which appeared in the columns of the reputed World's Greatest Newspaper recently.

"New York, Sept. 24—Bernays Johnson climbed into an electric chair at the Radio World's Fair, New Madison Square Garden, tonight. 'Don't get panicky,' he advised some 500 of the curious about his platform.

"Johnson carried a bar of Norway iron one-eighth of an inch thick. He adjusted the brass 'death chair' helmet over his head, completed the circuit by placing his shoes (leather soles) on a spread of copper and waited for 350 amp. and 2200 v. to be sent through his body while he held the bar of iron in his mouth.

"The 'executioner' turned on the switch. The bar of Norway iron grew white hot and melted away. Hundreds saw it. Johnson's body swayed a bit and he looked extremely uncomfortable. Then, after a minute had elapsed, the current was turned off and Johnson rose. When he opened his mouth it could be seen that his tongue was bleeding profusely.

"The amperage that flowed through Johnson, it was stated, was three times that meted out to a murderer in the Sing Sing chair, and five times that needed to run a trolley car. Johnson, it was said, has been around laboratories so long that he has become immune to electric shock."

Just why the immune Mr. Johnson chose to chew on a bar (⅛ in. thick) of Norway iron while enacting the role of an electric toaster nor how the 350 amp. managed to climb up through the leather soles of his shoes, we admit, is not quite clear to us, but Mr. Johnson no doubt had reasons of his own. A man of his constitution no doubt needs a lot of iron in his system and perhaps he doesn't care for raisins. Just how Mr. Johnson would be classified as a conductor is somewhat difficult to decide—probably one of the third class, personally, we would say 9th rate—but of course that isn't for us to decide. Disregarding mere details, however, Mr. Johnson is to be congratulated upon his speedy recovery. It is fortunate for society that he chooses to lead a lawful life, since it is evident that Sing Sing's "smoky seat" would hold no terrors for him.

Less spectacular but none the less marvelous is the following stupefying announcement attributed to the Pennsylvania Public Service Information Committee, as reported in a recent news bulletin:

"For a long time electrical engineers have known of a constant loss in transmitting electricity, remarks the Pennsylvania Public Service Information Committee. It has been noted that the loss is greater in heavily-loaded street cars. Internationally famous scientists now claim that this electrical loss is absorbed by the human body, and is a great health producer, according to the American Electric Railway Association.

"Instead of going to the beauty parlors for electrical treatment, ladies will find great benefit from riding the street cars, according to the Association. It has been noted that men who work around electrical generating plants are rarely sick. The men working on electric street cars have a high health record. All of which tends to substantiate the theory advanced by scientists, the Association esserts."

Thus another profound mystery is dealt a knockout. Think of it! For years we have been riding around on street cars at a nickel a ride and in that time we have absorbed thousands of kilowatts of perfectly good health-giving electricity for which the company charges us nothing. Here, indeed, is "Service Plus" in its most magnanimous form. Hail to the new slogan, "Ride on Street Cars to Keep Healthy." What a blow this news must be to the bus operators!

So, day by day the newspaper boys manage to keep alive our interest in a subject which at best only has a speed of 186,000 miles per second and which without their aid would be intolerably dull. To be sure, in the great electrical research laboratories of the General Electric, Westinghouse and Bell Telephone Companies, the scientists occasionally "pull off" a piece of passable work, but compared to the brilliant electrical emanations which radiate from the newspaper rooms throughout the country, this is nothing.

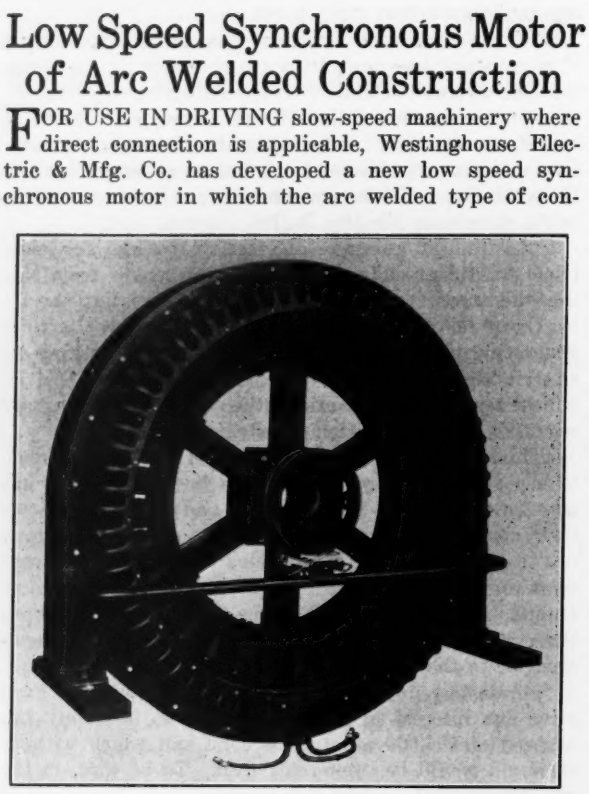
In its discussion of Industry, the World Economic Conference at Geneva stated that the present industrial difficulties of Europe are not due to an inadequacy either of scientific invention or of raw material, but to a lack of sufficient capital and to an inadequate market for the productive capacity of many industries. The Conference considered its central problem to be the lowering of production costs and therefore prices, with the object of securing a better equilibrium between plant capacity and demand, without injuring either the consumer or the worker.

By virtue of the size, number of bearings and bulky nature of many large, heavy machines, it has been deemed advisable in many cases to devise some form of positive automatic lubrication. Greater convenience results with frequent marked saving in labor, due to reduction in the amount of attention necessary.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Low Speed Synchronous Motor of Arc Welded Construction

FOR USE IN DRIVING slow-speed machinery where direct connection is applicable, Westinghouse Electric & Mfg. Co. has developed a new low speed synchronous motor in which the arc welded type of con-



NEW WESTINGHOUSE TYPE HR LOW SPEED ARC-WELDED SYNCHRONOUS MOTOR

struction has been used to a high degree. While arc-welding has been used to some extent in Westinghouse motors for 15 yr., it reaches its greatest application in this motor. Its parts have been specially designed for ease in handling and ease in assembling in the field.

This motor has been designed for high efficiency at all loads within its normal operating range. High efficiency at fractional loads is a great power saver since few applications require the maximum output of the motor. The excitation has been materially reduced, thus increasing the efficiency and cutting operating costs.

A starting torque of 50 per cent and a pull in torque of 40 per cent are features of this new motor. The higher the starting torque, the quicker the motor will come up to normal running synchronous speed. The disturbance on the line is correspondingly reduced. This high torque is also a valuable asset under such unusual conditions as starting a machine while it is still new and stiff or after it has been standing for a considerable time.

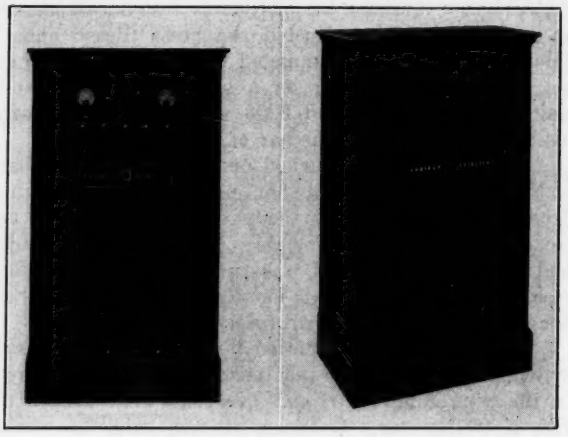
Low speed motors naturally have very little windage effect so that cooling is effected largely by radiation. As heat has a deteriorating effect on insulation, a cool running motor will have a long life. The shape of the rotor arms in this new motor is such that a large amount of air is set in motion. This cooling air is so directed that it not only passes through the stator coils but it also passes over a large area of the stator laminations as well.

A means of varying the flywheel effect is an attractive feature of the new, type HR, synchronous motor. By means of different weight rings bolted to the rotor rim, six possible values of flywheel effect are available.

This motor is particularly desirable for driving refrigeration machines and air compressors, although in the coupled type it is equally desirable for driving Jordans, pulp-grinders, pumps and other slow speed machinery.

Smoke Detector Gives Fire Protection

BASED upon the principle of reflected light and television the Rich portable smoke detector has been developed by Walter Kidd Co., Inc., 140 Cedar St.,



TWO VIEWS OF THE ASSEMBLED SMOKE DETECTOR

New York, to protect all types of rotary machines and automatic substations from fire.

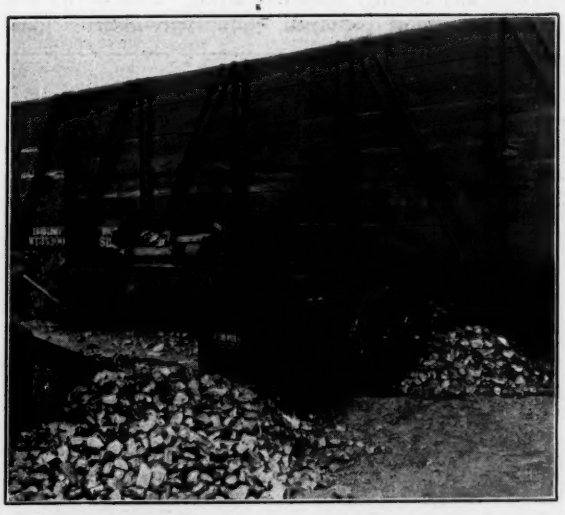
A continuous sample of the air from the space protected is passed through a beam of light placed so that it does not illuminate a photo-electric film. If, however, smoke particles are present in the air sample, they act as a reflecting medium and throw light upon this film, causing its resistance to decrease and resulting in

a current increase which sounds an alarm gong. This apparatus can also actuate mechanism to operate the Lux Inert Gas Extinguishing System or still other mechanisms to stop the rotary machines. Smoke from an ordinary safety match is more than sufficient to operate the alarm.

More than one generator can be protected by a single smoke detector by installing a correcting device. When used in unattended substations, the alarms and detector may be separately wired to the central station or tied in with the supervisory system of the substation as desired.

Wagesaver Car Unloader Designed to Handle 60 T. an Hour

GIFFORD-WOOD CO., Hudson, N. Y., has recently put on the market the Wagesaver car unloader. This machine is primarily an especially designed flight conveyor, with a long flat tail, to extend across the rails under the hopper of a bottom dump car and to feed the coal onto the tail end of a portable conveyor for delivery to truck or stock pile. It is designed to handle all sizes and grades of coal, as well as coke, from slack up to 16-in. lumps, at an average rate of 60 t. an hour.



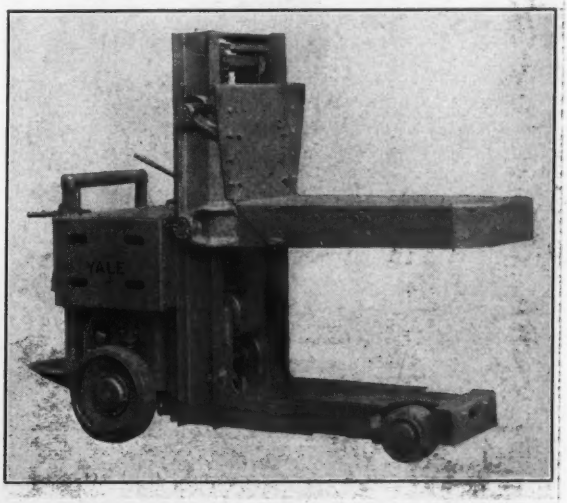
WAGESAVER CAR UNLOADER IN OPERATION

The car unloader consists of a double chain flight conveyor contained in a steel body mounted on an adjustable truck, and driven by a 5-hp. ball-bearing electric motor. The conveyor is 18 in. wide and is made up of 2 in. steel channel flights mounted, every 12 in. between two strands of 1½ in. pitch heavy steel roller chain. The full width of 18 in. is available for pushing the coal. The flights travel over a continuous $\frac{3}{16}$-in. steel plate on which the coal drops. The flights moving over this plate push the coal before them out from under the car hopper and up a short incline to the delivery end, where it is discharged onto the loading end of another conveyor. All bearings are lined with phosphor bronze bushings, and the Alemite pressure system of lubrication is used throughout. A safety shear pin is provided in the drive machinery.

3-T. High Lift Truck

TO FULFILL THE requirements for ever increasing loads on electric industrial trucks, the model K25, 3-t. high-lift elevating truck has been added to its line by the Yale & Towne Mfg. Co., Stamford, Conn.

Backbone of the framework comprises mainly a large gusset plate, one-half inch thick and this plate is approximately 24 in. high. In addition to forming the framework, it provides a yoke to serve as a guide for the drive unit and the spring suspension of the truck. Structural parts of the truck are joined with ⅝-in. and ¾-in. rivets.



LARGE GUSSET PLATE FORMS BACKBONE OF TRUCK FRAMEWORK

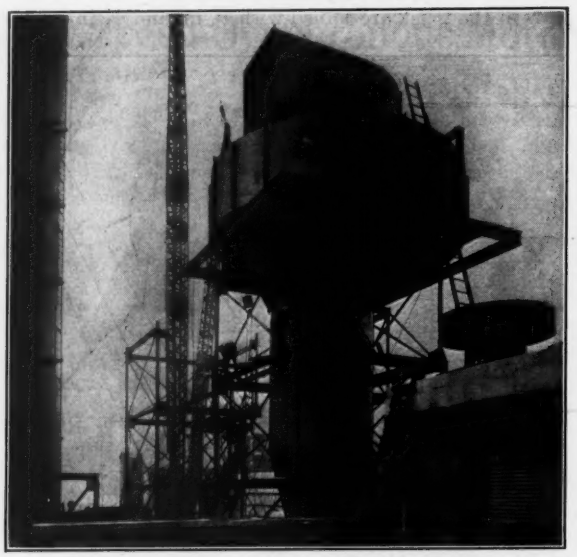
Elevating platform is raised and lowered by a 1½-in. diamond roller chain, passing over a power-driven sprocket at the bottom, and an idler sprocket at the top. Hyatt heavy-duty roller bearings are employed in the idler sprocket. Hoisting motor is connected to the spur-gear pinion through a spring ratchet, so arranged that a positive drive is obtained when raising the elevating platform. Speed of 7½ ft. a minute is obtained when lifting a full load and a speed of 19 ft. a minute when raising the empty platform. The lowering speed is 19 ft. a minute loaded or empty. Main drive unit is of the double reduction spur-gear type, driving the wheels through totally enclosed universal joints. The entire gear reduction with its differential and bearings run in a bath of oil. A four-wheel steer feature allows a turning radius of 96 in. to the outside edge of the truck.

ARKANSAS UTILITIES CO. at Helena, Ark., is enlarging its electric light plant. One new 600-hp. Walsh & Weidner boiler is being installed, with space for another boiler, to be added in the near future. This boiler will operate at 250 lb. pressure and 100 deg. superheat. The boiler will be fired by coal, using Stowe chain gate stokers. A new 2500-kw. Westinghouse turbine is also being installed.

At present this plant is using four 300-hp. boilers, one 1500-kw. turbine and two 500-kw. turbines. The new installation is under the supervision of Jack Abbott, superintendent of power for this company, and will be in operation by January 1, 1928.

Sirocco Collector for Fly Ash and Coal Dust

AMONG THE PROBLEMS that accompany the present rapid developments in the art of coal burning is that of preventing discharge from chimneys of fly ash and coal dust, both in central stations and in industrial plants. As a solution of this problem, the American Blower Co., Detroit, Mich., has placed on the



TYPE D COLLECTOR UNDER ERECTION

market the Type D Sirocco collector. One of these under erection is shown herewith.

This apparatus consists of main chamber of volute shape and below this a series of alternating truncated cones and cylinders, terminating in a dust outlet at the bottom. Dust laden air or gas enters the upper chamber tangentially and clean air leaves from a central opening at the top. The design is intended to cause the dust laden air or gas to take a path following the shape of the volute and to force the heavier dust outward and downward through the cylinders and truncated cones, to the dust collector at the bottom. Meanwhile, the cleaned air or gas is to form a vortex at the center of the collector and to pass upward and out. The arrangement is intended to produce centrifugal action without turbulence. The collector is described in more detail, together with data on its performance, in Bulletin 1028, recently issued by the manufacturer.

Morse Announces Improved Chain

MORSE CHAIN CO., Ithaca, N. Y., has announced an improved chain, the improvements being principally due to changes in the design of the rocker joint. The new design, 55 type chain, is intended to run on all sprockets, the new link being the same length and height as the old. The new joint, shown herewith, operates on the same principle as the original Morse rocker joint. The seat pin, at the left, has been enlarged to give greater bearing surface and also to make it a stronger transverse member to hold the chain together. The rocker pin, at the right, has been changed in contour, to give a better surface of contact with the links.

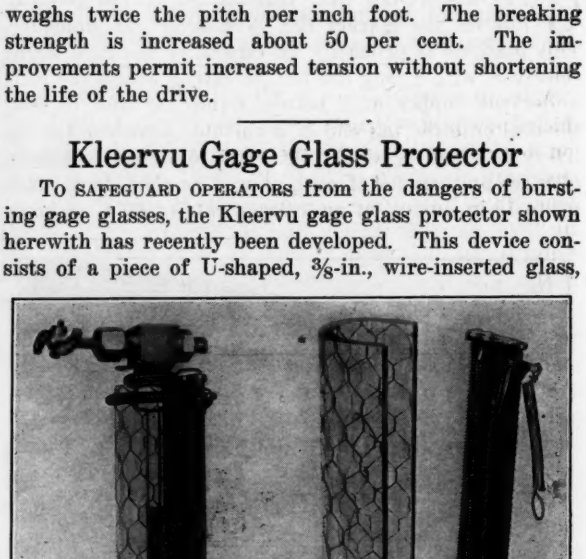
Combined joint members are designed to give a more nearly round hole with reduced clearance to hold the links more securely on the pins, and, by better balanced joint, to produce a smoother running chain. Joint pins are about 8 per cent heavier and the complete chain

SEAT PIN HAS BEEN ENLARGED AND CONTOUR OF ROCKER PIN CHANGED

weighs twice the pitch per inch foot. The breaking strength is increased about 50 per cent. The improvements permit increased tension without shortening the life of the drive.

Kleervu Gage Glass Protector

TO SAFEGUARD OPERATORS from the dangers of bursting gage glasses, the Kleervu gage glass protector shown herewith has recently been developed. This device consists of a piece of U-shaped, 3/8-in., wire-inserted glass,



SCREEN AT BACK IS DESIGNED TO STOP FLYING GLASS

completely enclosing the gage glass and a heavy wire screen behind the glass to prevent broken glass from flying. Heavy springs attached to brackets on the screen pass around the packing nuts and a second spring at top and bottom holds the glass protector in place. The device is designed for installation without the use of tools. The protector is available for all kinds of gages, such as those on chemical containers, steam separators, air receivers and the like. It is manufactured by Wright-Austin Co., 315 W. Woodbridge St., Detroit, Mich.

THE RUSSELL, BURDSALL & WARD BOLT & NUT CO., Port Chester, N. Y., plans to build a boiler plant at its new local mill. The Austin Co., Euclid Ave., Cleveland, Ohio, has general contract for buildings.

Spray Pond Has Capacity of 32,400 G.p.m.

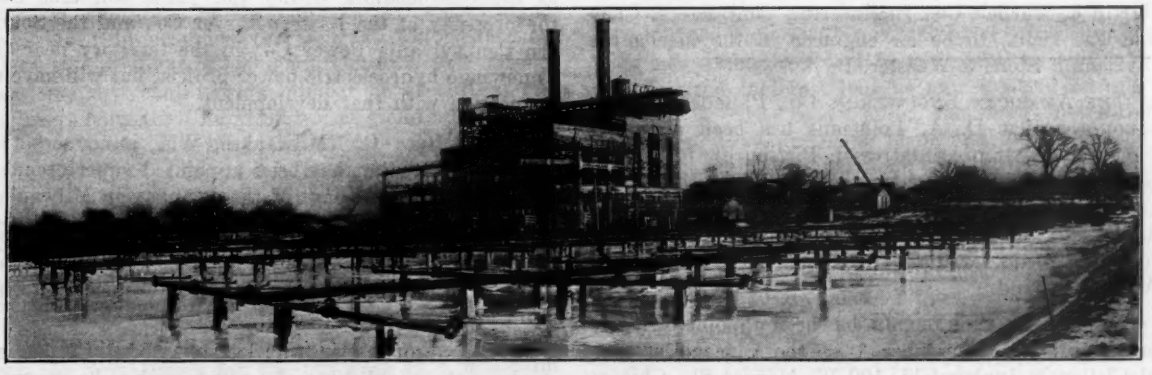
ONE OF THE LARGEST single spray pond installations made by a public utility during the year 1926 is the Marley system installed by the Power Plant Equipment Co. of Kansas City, Mo., at the Whippany Station, Jersey Central Power & Light Co. This station was described in detail in the August 1 issue.

Each of the two 10,000-kw. Allis-Chalmers generating units requires two of the four sections into which the pond is divided. Each of these four sections has a capacity of 8200 g.p.m., giving a total circulating capacity of 32,400 g.p.m. for the entire pond.

Due to the unusual size of the installation with resulting problems of air circulation, spacing between the laterals was increased considerably over that ordinarily considered standard for spray pond work. Large air mains were also provided between each of the four main sections.

Make-up water is provided by the Whippany River which flows past one side of the pond. Due to its location and surroundings, it was necessary to give serious consideration to clogging. The free sectional area through the Marley spray nozzle is large enough to pass any solid material which will go through the tube section of the surface condensers.

No concrete basin was provided, but the low ground was simply excavated and concrete piers conveniently located for the installation of the spray system. The pond, with a total area of some 95,000 sq. ft., is made up of 800 2-in. spray nozzles with a capacity of 40.5 g.p.m. each. These nozzles are placed 5 ft. above the water level, designed for an operating pressure of 6¼ lb. and for a cooling effect of 12 deg. F. at full load. It is estimated that the makeup water will be about 486 g.p.m.



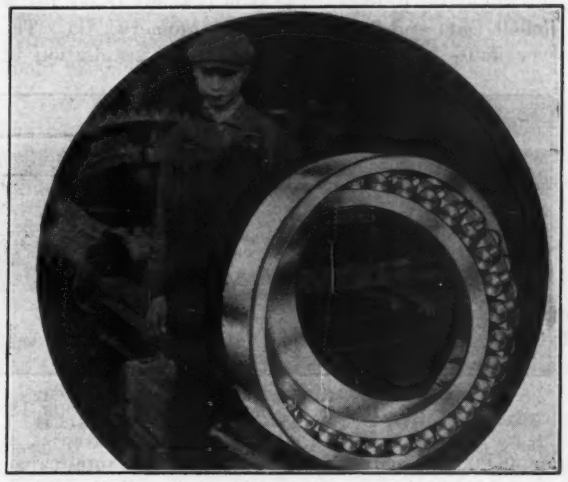
GENERAL VIEW OF WHIPPANY STATION SHOWING DETAILS OF THE SPRAY POND INSTALLATION

This, of course, is not continuous, as the spray pond is used only intermittently during such periods of the year as the flow in Whippany River is not sufficient to provide water enough for cooling purposes.

THE NEW ENGLAND GAS & ELECTRIC ASSOCIATION, operated by the Associated Gas & Electric Co., New York, is arranging for the purchase of the Cape & Vineyard Electric Co., Falmouth, Mass., and the Portsmouth Power Co., Portsmouth, N. H. Warren Partridge is vice-president.

Large Roller Bearings Run Successfully for Three Years

TWO HUGE SKF SPHERICAL BEARINGS, of the type shown in the accompanying photograph, have been successfully operating for a period of over three years in a



SPHERICAL BEARING THREE FEET IN DIAMETER

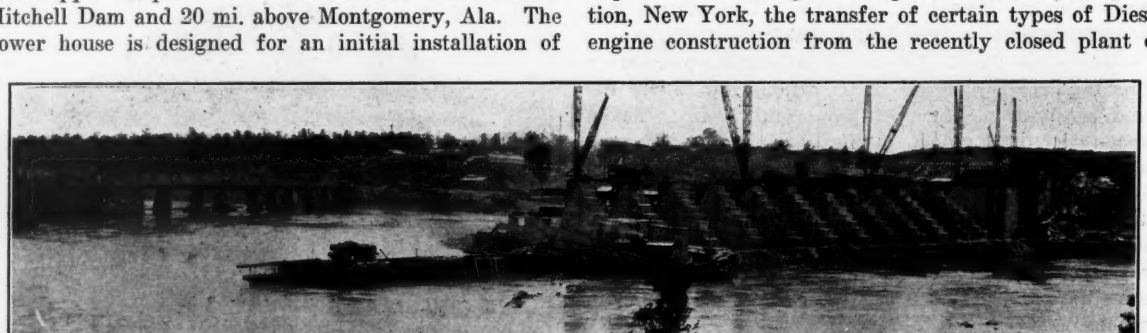
"cylpeb" cement mill at the plant of the Dexter Portland Cement Co., Nazareth, Penna. These bearings, almost three feet in diameter, are carrying the load of a 5½-ft. by 26-in. tube mill used in pulverizing. The mill is driven by a 250-hp. motor at 26 r.p.m. The load is 50 t. or 25 t. per bearing.

During the three-year period, these bearings have been on the job continuously and the only attention required has been replenishing of lubricant several times a year.

SKF spherical bearings are designed to be self-contained and non-adjustable units. These bearings are made of high carbon chrome steel, uniformly hardened throughout. The rollers are of a barrel shape and each of the two rows of rollers is permitted to operate independently of the other. The rollers and races are made from charcoal steel, a product of the SKF iron ore mines and steel mills in Sweden. Each roller is drop-forged and individually turned between centers.

Construction of Lock 18 Plant of Alabama Power Co.

CONSTRUCTION WORK is proceeding rapidly on the Lock 18 hydro-electric development of the Alabama Power Co. on the Coosa River in Alabama. The accompanying illustration shows how the dam and power house appear at present. The dam is about 18 mi. below Mitchell Dam and 20 mi. above Montgomery, Ala. The power house is designed for an initial installation of four 36,000-hp. hydraulic turbines, giving a total capacity of 144,000 hp., and an ultimate installation of six units developing 216,000 hp. It is expected that the first unit will be in service by Dec. 1, 1928.



GENERAL VIEW OF LOCK 18, POWER HOUSE IN BACKGROUND

News Notes

STONE & WEBSTER, INC., Boston, Mass., announces that W. Poole Dryer, formerly designer of large steam turbines with the General Electric Co., has become a member of the Mechanical Division of Stone & Webster, Inc., at the Boston office. It also announces that A. W. Atwater has withdrawn from membership in the firm of Martin & Warlick Co., Engineering Contractors, Chattanooga, Tenn., to be an engineer in the Mechanical Division of Stone & Webster, Inc.

THE AMERICAN ENGINEERING CO., Philadelphia, Pa., announces that D. A. Polhemus has been appointed direct factory representative in Pittsburgh for its Lo-Hed hoist division, with an office in the Oliver Bldg. He will be assisted by John Kaiser. W. C. Minier will direct sales of this equipment in northern Ohio, except for the Toledo territory, with office at 2195 Bellfield Ave., Cleveland.

WILLIAM BLANCHARD, JR. has been appointed district manager as of September 1 of the Chicago office of McClellan & Junkersfeld, 100 W. Monroe St., Chicago, Ill.

THE COFFIN VALVE CO., Boston, Mass., announces the appointment of The Chapman Valve Manufacturing Co. as its exclusive sales agents in the United States, Canada, Mexico and Cuba.

THE CARBORUNDUM CO. of Niagara Falls, N. Y., has purchased the controlling interest in The American Resistor Co. of Milwaukee, Philadelphia and New York. The principal products of The American Resistor Co. are non-metallic electrical heating elements and resistors which are marketed under the trade name of "Globar." The new company will be known as Globar Corporation and has been incorporated under the laws of New York State. Present manufacturing facilities of the old company will be moved to Niagara Falls, N. Y., where a new plant will be erected in connection with the plant of The Carborundum Co.

ACCORDING TO A RECENT statement by President Belnap of the Worthington Pump and Machinery Corporation, New York, the transfer of certain types of Diesel engine construction from the recently closed plant of Blake and Knowles at Cambridge to the enlarged Snow works in Buffalo is the latest step in concentrating facilities for increased efficiency. The Snow plant has been completely renovated and the best of the Cambridge plant equipment has been moved in and installed in space newly provided. To meet the demand for additional power, a new large power plant has been built. The foundry and shops have been modernized and complete testing equipment provided.

OFFICIALS OF the Philadelphia Electric Co., Tenth and Chestnut Sts., Philadelphia, Pa., are organizing a subsidiary interest under Delaware laws, to be known as the Susquehanna Utility Co. This will take over the property of the Eastern Power Co., and the Southern Pennsylvania Power Co., in the territory near the Conowingo hydroelectric power project, but will have no connection with that development.

CHAIN BELT CO., Milwaukee, Wis., announces that Luther H. Bosnian has been appointed superintendent of the Park Street Plant of the company in Milwaukee.

THE CLIMAX ENGINEERING CO., Clinton, Iowa, has appointed John Reiner & Co., Inc., 309 Church St., New York, N. Y., as its representative for Connecticut, New York and New Jersey.

WESTINGHOUSE ELECTRIC INTERNATIONAL CO. has announced the establishing of a new branch to be known as the Compania Electrica Westinghouse de Chile, with activities in the countries of Chile and Bolivia. E. L. McCloskey, formerly manager for China of the Westinghouse Electric International Co., has been appointed manager of the new branch with headquarters at Santiago, Chile. He sailed for his new headquarters on August 27.

CONSTRUCTION WORK on the hydro-electric development of the Northern States Power Co. at Chippewa Falls on the Chippewa River has been started under the direction of Byllesby Engineering and Management Corp. according to an announcement by H. W. Fuller,

Vice-President. Chippewa Falls plant will have a capacity of 30,000 hp. in six units of 5000 hp. each. These will operate under a head of 30 ft. The dam and power house will be located in Chippewa Falls about 3 mi. below the Wissota development and will operate synchronously with the latter.

DAYTON-DOWD CO., Quincy, Ill., announces the appointment of Robert L. Eltringham, Pacific Gas & Electric Bldg., San Francisco, as its representative in Northern California. The company has also appointed W. L. Vansant and Stuart Goldsborough, Farmers Bank Bldg., Pittsburgh, Pa., as its representatives in that district.

THE W. B. FOSHAY CO., Minneapolis, Minn., has negotiated for the purchase of additional properties in Arizona, Idaho and Montana.

THE BUREAU OF YARDS AND DOCKS, Navy Dept., Washington, D. C., is asking bids (no closing date specified) for power house equipment for the submarine base at Pearl Harbor, T. H., as per Specification 5481.

THE ROCHESTER GAS & ELECTRIC CORP., Rochester, N. Y., is carrying on work of increasing the capacity of its hydroelectric plant No. 5 on the Genesee River by addition of a 28,000-hp. unit, giving the plant a total capacity of 60,000 hp.

THE CAMDEN RAIL & HARBOR TERMINAL CORP., Camden, N. J., organized by Fred Cohen and associates a few months ago under the name of the Camden Terminal Corp., has plans for a new cold storage terminal warehouse and refrigerating plant in that state. The main unit will be a nine-story building, 100 by 250 ft., for the cold storage division.

ACCORDING TO REPORTS the First Steel & Power Show of Canada held at the Varsity Arena, Toronto, August 31 to Sept. 2, proved a great success. Over 7000 representative engineers in the power and mechanical engineering field attended the show at which were exhibited the products of 300 manufacturers. The attendance included considerable number of executives and engineers from the United States, England and Europe.

Immediately following the official opening of the show, Dr. F. C. Langenberg, research engineer, U. S. Army, Watertown Arsenal, Watertown, Mass., gave the first address on "Where Are We Going in Metallurgy." Other speeches on standardization, safety and many technical subjects followed. Among the speakers were several prominent American engineers.

CONTRACT has been signed by the Public Service Corp. of New Jersey for the purchase of a minimum of 10 billion feet of gas during the next 10 yr. from International Combustion Engineering Corporation's new low temperature coal carbonization plant to be located at New Brunswick, N. J. This plant will be the first of the kind in this country, although the process has been in successful commercial operation for several years in Germany. It will handle 250,000 t. of bituminous slack coal a year, the initial installation being of 8 units. As a by-product the plant will produce 6,000,000 gal. of coal tar a year, all of which has been contracted for by F. J. Lewis Mfg. Co. of Chicago. From this tar 1,250,000 gal. of crude motor spirits and 2,750,000 gal. of heavier distillates will be produced, the distillates being used as wood preservatives and for the manufacture of disinfectants and other commercial products. After distillation of the by-products, there will be marketed 175,000 t. a year of domestic smokeless fuel similar in characteristics to anthracite coal, but with lower ash content.

THE OZARK UTILITIES CO., Pleasant Hill, Mo., J. K. Green, president, has preliminary plans for a new hydroelectric plant near Osceola, Mo., reported to cost about $200,000.

THE WEST TEXAS UTILITIES CO., San Angelo, Texas, has completed the construction of the first unit of a new steam-operated generating plant on the Concho River with initial capacity of 8000 hp. It is designed for an ultimate capacity of 30,000 hp.

Books and Catalogs

UTILIZATION of Blast Furnace Slag in Highway Improvement, by Clarence E. Bardsley, Sc.D., Assoc. Prof. Civil Eng'g, Missouri School of Mines, Rolla, Mo. 6 by 9 in., paper, 115 pages, illustrated.

History of the use of slag is sketched, a description given of its manufacture and its uses discussed. Tables summarize the specifications for slag in highway construction and an abstract is given of tests on slag, their interpretation and conclusions.

In 75 pages is given an extensive bibliography of the subject, arranged alphabetically and chronologically.

Professor Beardsley has shown the possibility of a use for the great slag heaps found in blast furnace territory and offers a new material to highway engineers. Copies of the bulletin may be had by writing to the Librarian of the School.

SERIAL REPORT on Pulverized Fuel for August, 1927, of the Prime Movers Committee of the National Electric Light Association, 29 W. 39th St., New York City, has just been issued. This contains data obtained from many new pulverized fuel burning stations and tables of pulverized fuel installations now existing or under construction. The report states that many new direct fired installations are being made and that there is an increase in the use of turbulent type burners, preheated air and water cooled furnace walls. Data on methods of sampling pulverized fuel are contained in the statements by both operating companies and manufacturers and a bibliography of recent literature pertaining to pulverized fuel is appended.

AMERICAN SOCIETY FOR TESTING MATERIALS, 1315 Spruce St., Philadelphia, Pa., has recently issued a pamphlet containing a reprint of report of Committee D-9 on electrical insulating materials and methods of test relating to electrical insulating materials. The book gives a comprehensive report on the activities of the committee with details of standards and tentative standards now in force regarding this important subject. As an appendix there is a description of the latest method of making a life test of transformer oils. Pamphlet contains about 130 pages and copies may be obtained at a nominal price from the Society at the above address.

IN AN INTERESTING pamphlet on Our Runaway Rivers, Put Them to Work, Jones and Laughlin Steel Corp. of Pittsburgh, Pa., summarize the extent to which

the Mississippi, Ohio and other rivers in the south are being utilized for freight and passenger transportation and emphasize the savings to be made by further extension as to volume of shipments and extent of area covered by this service. A multitude of illustrations show the barge service, landing and transfer facilities at various river ports and the great tonnage now being handled. Proper flood control will not only safeguard property along the rivers but will build up a system of waterways more than 9000 mi. in extent to furnish low-cost transportation.

JOINT COMMITTEE OF NATIONAL UTILITY ASSOCIATIONS, 420 Lexington Ave., New York, has just issued two booklets, edited by Frank Bohn, on the Boulder Dam project. One of these books is entitled "Boulder Dam from the Origin of the Idea to the Swing-Johnson Bill" and contains a complete bibliography, references, engineers' studies and reports, text of the Swing-Johnson Bill, minority reports and general comments. The other, entitled "The Essence of the Swing-Johnson Bill," contains data on the various proposals urged by Congress for the development of the Colorado River.

THE INTERNATIONAL NICKEL CO., 67 Wall St., New York, N. Y., has issued two bulletins, one describing the Wright Whirlwind Engine and the other the Duesenberg Racing Car. These bulletins discuss in detail the types of steel used for various services in this equipment and the properties developed for such use will doubtless be of interest to engineers working in other fields.

ELLIOTT CO., Jeannette, Pa., has just issued Bulletin-P, a 34-page illustrated catalog describing centrifugal blowers and compressors, containing complete details and illustrations of the various parts of the equipment and interesting photographs of installations. Curves of performance and engineering data are also included.

THE BROWN INSTRUMENT CO. in a recent bulletin discusses an installation of electric flow meters which costs 17c a day and saves almost $17.00 a day.

CARRICK ENGINEERING CO., 538 S. Clark St., Chicago, Ill., has just issued a booklet containing the context of a talk by J. W. Murphy entitled "Automatic Combustion Control and its Relation to Lower Steam Costs." This was delivered before an annual assembly of the engineers of a large manufacturing company.

THE BINKS SPRAY EQUIPMENT CO., 3114 Carroll Ave., Chicago, Ill., has perfected a spray cooling tower, described in Bulletin 5-E, especially adapted for cooling small quantities of water for Diesel engines, transformers, small refrigeration plants and other applications where the quantity of water does not exceed 100 g.p.m.

VALUABLE TABLES on corrective kv.a. required for various ratings of three-phase, 60-cycle CS squirrel cage induction motors are included in the Westinghouse Leaflet 20,286-A. The leaflet is on static condensers for power-factor correction on motor circuits and contains descriptions and illustrations of the various types of condensers.

FROM INGERSOLL-RAND CO. of Phillipsburg, N. J., is received a circular describing ER air and gas compressors in sizes from 4 by 4 in. to 20 by 12 in. with capacities from 28 to 1084 cu. ft. per min. Internal construction and various methods of drive are illustrated. This circular or catalog No. 3050, giving more complete information on this line of horizontal compressors, may be had by writing to the Ingersoll-Rand Co. at the above address.

C-E FIN FURNACE for steam generation, with water-cooled walls, is described in a new catalog just received from Combustion Engineering Corp., 200 Madison Ave., New York City. The catalog shows the arrangement of the furnace, also details of the fin wall construction and method of installing the furnace under various types of water tube boilers. Copies may be had on request set to the Combustion Engineering Corp.

BULLETIN 4-E of the Schutte & Koerting Co., 1156 Thompson St., Philadelphia, Pa., covering steam jet exhausters, primers and compressors is illustrated with colored section views showing the construction and operation of the equipment, also has tables of sizes and capacities and shows uses and arrangement for applications to pumps, condensers, siphon systems, evaporators, filters, storage tanks and washers. Copies are available by application to the company at the above address.

CONVEYORS CORP. OF AMERICA, 326 W. Madison St., Chicago, in a recent 16-page catalog, describes the American steam jet ash conveyor, giving details of its construction and photographs and drawings of typical installations.

GENERAL ELECTRIC steam turbines of from 2000 to 6000 kw. capacity are described in a new bulletin, GEA-598, recently issued by the General Electric Co., Schenectady, N. Y.

RUGGLES-KLINGEMANN MFG. CO., Salem, Mass., has issued a 4-page illustrated bulletin describing solenoid operated valves and servo motors.

CHAS. CORY & SONS, INC., 185 Varick St., New York City, has issued the third edition of its bulletin 201-29-C, describing and illustrating seamless flexible metal hose for all services.

THE PARKER APPLIANCE CO., 10320 Berea Rd., Cleveland, Ohio, in a recent 16-page illustrated booklet describes Parker tube couplings for copper tube employed on various water and gas services.

GILLIS & GEOGHEGAN, 537—39 W. Broadway, New York, in a recent 24-page illustrated bulletin describes the G & G Telescopic Hoist for removal of refuse from cellar to grade level.

EVERBRITE, a casting metal, resistant to corrosion and erosion which takes a high polish is described and its uses illustrated in a booklet issued by American Mond Nickel Co., Clearfield, Pa.

EHRET MAGNESIA MFG. CO., Valley Forge, Pa., in an 80-page book, describes various Ehret magnesia products for insulation of all hot and cold surfaces.

G & G ATLAS SYSTEMS, 534 W. Broadway, New York, has just issued leaflets 2300-A and 2600-B, describing its pneumatic dispatch system.

FRICK CO., WAYNESBORO, PA., has issued a publication entitled "Ice & Frost," Number 102-A of this publication describes and illustrates small refrigerating machines for various commercial services.

A Feast of Reason and a Flow of Information

POWER PLANT ENGINEERING takes pleasure in announcing to its readers the publication of the Third of its great Series of Feature Numbers.

To broaden the thinking, to show general trends during the past year and to be of the greatest possible helpfulness to readers in improving results in their plants and advancing their standing in the engineering world, the editors of Power Plant Engineering, its correspondents in all parts of the country and other authorities in their respective lines are giving their best efforts.

Informative advertisements of the leading manufacturers will supplement the editorial information given in each Feature Number and make these numbers of extreme value for the men in the field who will plan, build and operate the large plants of the country.

That there are ever greater opportunities for the men of keen knowledge and sound judgment is attested by the continuation of new financing, construction and rehabilitation of plants. For these purposes $2,091,399,872 was expended in the year ending October 1st, 1927, which was practically the same amount as for the year before.

New records for low cost per unit of output have been set since the last series of Feature Numbers, and new methods, machinery and equipment have been developed.

FAMILIARIZE yourself with the nature of the exhibits and their location through the Nov. 15, 1927, New York Power Show Directory Number. This, the 1st Feature Number, will reach you three weeks in advance of the show, which will be held from Dec. 5 to 10 in the Grand Central Palace, New York.

In this number you will find advance information, both in the editorial and advertising pages, which will enable you to go directly to the booths where the products most useful to your plants are exhibited.

This direct method will save you time which you may use to attend the meetings, talks and motion pictures that will be given in connection with the show.

YOU are cordially invited to Power Plant Engineering's Booth No. 99 where you will find copies of the Dec. 1, 1927, New York Power Show Number being distributed.

This number will contain floor plans of the exhibition by which you can quickly locate the particular exhibits you have decided to study.

Together with the Nov. 15, New York Power Show Directory Number, this 2d Feature Number will visualize the New York Power Show to all of the 23,000 power plant men who will receive it. It will bring information about the show to you who are unable to attend.

November 15, 1927
New York Power Show
Directory Number

December 1, 1927, New
York Power Show Number

December 15, 1927
Annual Review Number

January 1, 1928, Power
Plant Performance Number

January 15, 1928, Power
Plant Equipment Number

February 1, 1928
Chicago Power Show
Directory Number

February 15, 1928, Chicago
Power Show Number

THREE annual numbers, covering engineering progress, will follow, each of immediate interest and all of reference value.

The year's Annual Review Number of the series, to be published Dec. 15, 1927, will bring the latest general practice up to date and indicate trends which leading executives will carefully consider in their plans for the future.

Among the subjects treated in this number will be Boiler Room Practice—furnaces, fuels, feed water and air supply. High Pressure Steam Station Practice—stage bleeding, condensers, size of units and steam reheating. Electric Station Practice—generators, cooling and switching. Hydraulic Station Practice, Trends in the Oil Engine Field, and the Distribution and Use of Power, covering sub-stations, interconnection and utilization, will each be treated in separate articles.

Tendencies in new stations will bring out facts of value to engineers and will help them in their work.

THE 4th Feature Number will be the Annual Specialized Reference and Textbook Number, published Jan. 1, 1928. "Power Plant Performance" will be its subject.

As the whole can be no greater than the sum of its parts, so each department of the plant will be studied in view of what may be expected of men and machines, to attain the highest performance records for the entire plant.

Records of performance of specific machinery, equipment and supplies and offers of helpful information to engineers will be found in the advertising pages of this issue. A more extensive outline of this issue will be given in a prospectus which will be published in the near future.

THE Power Plant Equipment Number, to be published Jan. 15, 1928, the 5th of the Series of Feature Numbers, will contain an exhaustive treatise on types of equipment, the use of which has helped to establish records of performances. Types discussed will include control and recording apparatus, steam turbines, oil engines, refrigerating apparatus, electric switching and other power plant equipment.

Manufacturers in the power plant field give their best skill and resources in developing the equipment that makes possible the new and higher records set by the builders and operators of modern plants.

The advertising pages of this number will give first-hand information concerning the products that have proved their usefulness in the great power plants of today.

THE Chicago Power Show Directory Number, to be published Feb. 1, 1928, will be devoted to the Annual Chicago Power Show to be held at the Coliseum, Chicago, Feb. 14 to 18.

This 6th Feature Number will aid you who attend the show to find the nature and location of every exhibit and select those exhibits you wish to see. In the advertising pages you may obtain further information on products that will be exhibited.

MEET the Feb. 15, 1928, Chicago Power Show Number at Power Plant Engineering's Booth No. 57, from which it will be distributed throughout the show.

Floor plans that will guide you directly to the exhibits you wish to see, complete information on motion pictures and talks to be given during the show and the manufacturers' own messages in the advertising pages will make the number a complete guide to those who attend.

Together, the Feb. 1st and Feb. 15th numbers will carry the Chicago Power Show to the home desks of all their 23,000 readers. To some it will be their only sight of the show, and to others a constant reminder of what they saw and heard at the show.

THESE 7 Feature Numbers will contain material that epitomizes the great power show, also engineering information that can only be co-ordinated and published annually. Regular subscribers receive these 7 Feature Numbers at no extra expense above the cost of their regular subscription.

To be sure of receiving the 7 Feature Numbers, see that your subscription is renewed if it is about to expire, as only a sufficient number of copies of any issue is printed to fill subscriptions and orders on hand at the time printing begins.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Steel Co., Bethlehem, Pa.
Binks Spray Equip. Co., Chicago.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner-Denver Co., The, Quincy, Ill.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa.
Sullivan Machy. Co., Chicago.
Worthington Pump & Mach. Corp., New York.
Yeomans Bros. Co., Chicago.

AIR COOLERS.
Spray Engineering Co., Boston.

AIR FILTERS
Connor Co., Inc., The W. B., N. Y.
Spray Engineering Co., Boston.

AIR PREHEATERS.
Air Preheater Corp., New York.
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., New York, N. Y.
Prat-Daniel Corp., New York.

AIR WASHERS
Buffalo Forge Co., Buffalo, N. Y.
Connor Co., Inc., The W. B., N. Y.
Spray Engineering Co., Boston.

ALARMS, HIGH AND LOW WATER
Hills-McCanna Co., Chicago.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland.
Wright-Austin Co., Detroit.

ANTI-CORROSIVE COATINGS
Dampney Co. of Am., Boston.

ARCHES, BOILER AND COMBUSTION
Brady Conveyors Corp., Chicago.
Carborundum Co., Perth Amboy.
Denver Fire Clay Co., Denver.
Detrick Co., M. H., Chicago.
Girtanner Engrg. Corp., N. Y.
Green Fire Brick Co., A. P., Mexico, Mo.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
Hoffi Co., M. A., Indianapolis.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y
Walsh Fire Clay Products Co., St. Louis, Mo.

ASH BIN GATES AND DOORS
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engrg. Corp., N. Y.

ASH HANDLING SYSTEMS
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Brady Conveyors Corp., Chicago.
Combustion Engrg. Corp., New York, N. Y.
Conveyors Corp. of Am., Chicago.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engrg. Corp., N. Y.
Link-Belt Company, Chicago.
Robins Conveying Belt Co., N. Y.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

ASH TANKS
Brady Conveyors Corp., Chicago.

BABBITT METAL
Magnolia Metal Co., New York.

BEARING METAL
Magnolia Metal Co., New York.

BEARINGS
National Tube Co., Pittsburgh.

BELT CONVEYORS
Jeffrey Mfg. Co., Columbus.
Robins Conveying Belt Co., N. Y.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BELT DRESSING
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELTING
Crandall Pkg., Palmyra, N. Y.
Quaker City Rubber Co., Phila.

BELTING, SILENT CHAIN
Link-Belt Co., Chicago, Ill.

BLOWERS, FAN & FURNACE
Air-Preheater Corp., New York.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Prat-Daniel Corp., New York.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, PORTABLE ELECTRIC.
Breuer Elec. Mfg. Co., Chicago.

BLOWERS, PRESSURE
Carling Turbine Blower Co., Worcester, Mass.

BLOWERS, PULVERIZED COAL
Buffalo Forge Co., Buffalo.

BLOWERS, STEAM
Schutte & Koerting Co., Phila.

BLOWERS, TUBE
Diamond Power Spec. Corp., Detroit, Mich.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Vulcan Soot Cleaner Co., Du Bois, Pa.

BLOWERS, TURBINE
Carling Turbine Blower Co., Worcester, Mass.
Elliott Co., Jeannette, Pa.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES
Boiler Engrg. Co., Newark, N. J.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Spec. Co., N. Y.

BOILER CAP CLEANERS
Lagonda Mfg. Co., Springfield, O.

BOILER CASING
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.

BOILER COATINGS
Dampney Co. of Am., Boston.

BOILER COMPOUND
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N.Y.
Paige & Jones Chem. Co., Inc., New York.

BOILER COMPOUND FEEDERS
Hills-McCanna Co., Chicago, Ill.

BOILER ENGINEERS
Boiler Engrg. Co., Newark, N. J.

BOILER FEED WATER, PURIFYING APPARATUS
Griscom-Russell Co., New York.
Paige & Jones Chem. Co., Inc., New York.
Permutit Co., New York, N. Y.

BOILER FRONTS
McLeod & Henry Co., Troy, N.Y.

BOILER MOUNTINGS
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Green Fire Brick Co., A. P., Mexico, Mo.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
Insulating Products Corp., N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refract. Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.
Rust Engrg. Co., Pittsburgh.
Walsh & Weidner Boiler Co., Chattanooga, Tenn.
Walsh Fire Clay Products Co., St. Louis, Mo.

BOILER TUBE CLEANERS
General Spec. Co., Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Hartford, Conn.

BOILER TUBES
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Murray Iron Works Co., Burlington, Iowa.
National Tube Co., Pittsburgh.
Reading Iron Co., Reading, Pa.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS
Botfield Refractories Co., Phila.
Insulating Products Corp., N. Y.

BOILERS
Babcock & Wilcox Co., N. Y.
Badenhausen Corp., Cornwells Heights, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Combustion Engrg. Corp., New York, N. Y.
Connelly Boiler Co., The D., Cleveland, O.
Erie City Iron Works, Erie.
Heine Boiler Co., St. Louis, Mo.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Ladd Water Tube Boiler Co., Pittsburgh, Pa.
Murray Iron Works Co., Burlington, Iowa.
Springfield Boiler Co., Springfield, Ill.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.
Wickes Boiler Co., Saginaw.

BOILERS, HEATING
Edge Moor Iron Co., Edge Moor, Del.

BOILERS, WASTE HEAT
Edge Moor Iron Co., Edge Moor, Del.

BOILERS, WATER TUBE
Edge Moor Iron Co., Edge Moor.

BOOKS & SCHOOLS.
McGraw-Hill Book Co., N. Y.

BRICKS, FURNACE LINING
Norton Co., Worcester, Mass.

BREECHINGS
Connery & Co., Inc., Phila.
Heine Boiler Co., St. Louis, Mo.
Littleford Bros., Cincinnati
Prat-Daniel Corp., New York.

BRUSHES, DYNAMO AND MOTOR
Dixon Crucible Co., Jos., Jersey City, N. J.
LeValley Vitae Carbon Brush Co., New York, N. Y.

BRUSHES, GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS
Brady Conveyors Corp., Chicago.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

BUCKETS, COAL HANDLING
Jeffrey Mfg. Co., Columbus, O.

CAR DUMPERS
Wellman-Seaver-Morgan Co., The, Cleveland, Ohio.

CARRIERS, PIVOTED BUCKET
Jeffrey Mfg. Co., Columbus, O.
Webster Mfg. Co., The, Chicago.

CASTINGS
Erie City Iron Wks., Erie.
Fuller Lehigh Co., Fullerton, Pa.
Girtanner Engrg. Corp., N. Y.
Hills-McCanna Co., Chicago.
Neemes Fdry., Inc., Troy, N. Y.

CEMENT, FURNACE
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Denver Fire Clay Co., Denver.
Green Fire Brick Co., A. P., Mexico, Mo.
Harbison-Walker Refract. Co., Pittsburgh.
Insulating Products Corp., N. Y.
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refract. Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., Inc., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.

CEMENT GUNS.
Cement Gun Co., Inc., Allentown, Pa.

CEMENT, HIGH TEMPERATURE
Botfield Refractories Co., Phila.
Denver Fire Clay Co., Denver.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
Johns-Manville Corp., New York.
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Quigley Furnace Spec. Co., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.

CEMENT, INSULATING
Insulating Products Corp., N. Y.

CEMENT, IRON
Smooth-On Mfg. Co., Jersey City.

CHAIN WHEELS
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE
Link-Belt Company, Chicago.

CHEMICALS, WATER TREATING.
Chicago Chemical Co., Chicago.
Permutit Co., New York.

CHIMNEYS
American Chimney Corp., N. Y.
Prat-Daniel Corp., New York.
Rust Engrg. Co., Pittsburgh.
Springfield Boiler Co., Springfield, Ill.

CIRCUIT BREAKERS
Cutter Co., The, Philadelphia.

CLEANERS, BOILER TUBE
General Spec. Co., Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

CLEANING COMPOUND
Dearborn Chem., Co., Chicago.

COAL AND ASH-HANDLING MACHINERY
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Brady Conveyors Corp., Chicago.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Chicago.

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